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In this issue: A study of the impact of suburban development upon residents' travel to the central business district of Washington, D.C.  
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**BUREAU OF PUBLIC ROADS**  
BERTRAM D. TALLAMY, Administrator  
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# Trends in Travel to the Central Business District by Residents of the Washington, D.C., Metropolitan Area, 1948 and 1955

BY THE DIVISION OF HIGHWAY PLANNING  
BUREAU OF PUBLIC ROADS

Reported<sup>1</sup> by JACOB SILVER,  
Transportation Economist

*This article evaluates the changes that took place between 1948 and 1955 in the relationship of the central business district to the metropolitan area. Many of the findings presented here, which are based on quantitative data, confirm the unsupported views of persons concerned with the changing urban structure.*

*Although the number of trips destined to the central business district increased during the 7-year period, the proportion of total area trips to the central area declined. Suburbanization, accompanied with development of commercial establishments, has had a definite impact upon the business center of the city. Although the central business district remained a major terminus for residents trips, it was less so in 1955 than in 1948.*

CENTRAL BUSINESS DISTRICTS in today's metropolitan areas are taking on new meaning in the urban structure. In the past 2 decades the urban population has increased at a very rapid rate, with a general tendency on the part of families to live farther from the central city. With this expansion has come a development of new outlying commercial and service facilities which, with an increased number of new employment centers outside the central business district (CBD), are now carrying on functions formerly associated with the central area.

What has been the impact of the growth of these functions upon the CBD and the travel to it? The need for information to answer this question has become increasingly important in order that planners and legislators may have a better understanding of the changing urban relationships in this very complex section of our cities. From the data obtained from the 1948 and 1955 home-interview travel surveys<sup>2</sup> which were sponsored by the Regional Highway Planning

Committee for metropolitan Washington, D.C., in cooperation with the Bureau of Public Roads, an attempt has been made to measure this impact as it relates to travel.

## Summary of Findings

The most important travel characteristic reflecting the change in the relative economic character of the CBD between 1948 and 1955 was the decreasing proportion of trips to the CBD in relation to total travel. The pattern in which the percentage of intra-area trips destined to the CBD decreased progressively with distance and varied with socioeconomic conditions and historical trends in a lateral direction around the CBD remained similar in both years. In 1955, however, residents of each of the geographical subdivisions studied made a smaller proportion of their intra-area trips to the CBD than in 1948. Although the CBD remained a land-use complex of major trip attraction, it was less an attractor of trips in 1955 than in 1948.

Of those residents who did make trips to the CBD, the more important changes in the geographical pattern of their distribution took place with distance from the central area rather than with direction. Although there were fluctuations in the directional distribution of CBD trips, the pattern in 1955 remained approximately the same as in 1948. The pattern of distribution as related to distance indicated a more significant shift, however, as an increasing percentage of the CBD trips were made by individuals residing at greater distances from the central area. These changes followed a pattern related to the distribution of population and residential growth, and also to the increasing uniformity in the frequency of trips per dwelling unit.

As indicated by the number of trips for each purpose, the functions carried on within the central area were changing. The retail segment of the CBD became relatively less important as the number of trips for non-retail activity increased and those for shopping decreased.

This does not imply that shopping trips to the central area will decline until they become insignificant. The volume of shopping trips should increase if greater accessibility to the

central area is provided and shopper convenience is improved. Nevertheless, by providing the same attracting forces outside the CBD that previously caused residents to make trips to the CBD, a greater choice in direction of movement has been given area residents.

Of those residents who were attracted to the central area for one purpose or another, the most notable change was the increasing use of the private automobile. The general increase in automobile ownership permitted a greater use of this mode of travel for all purposes for which trips would be attracted to the CBD. As automobile ownership increases in those subdivisions that were among the lowest in 1955, and as the number of trips to the CBD by individuals residing at greater distances from the CBD where transit service is less convenient increases, the use of the private automobile in traveling to the CBD should increase even more.

In Washington, D.C., as in other cities, many CBD functions have expanded into the fringe area surrounding the CBD because of increasing costs of land, rent, taxes, etc. As a result, many of the travel characteristics peculiar to the central area have become apparent in the fringe area. To obtain a more comprehensive picture of travel to the CBD, this area should be analyzed in future studies.

## Scope of Study

The metropolitan area of Washington, D.C., included in the 1948 transportation study is shown in figure 1. To develop travel data to the central area and to determine the relative effects of distance as well as direction upon a person's travel to the CBD, the study area was subdivided into rings and sectors. Sector divisions of the 1948 survey were used to indicate direction and 2-mile rings, as measured from the Zero Milestone,<sup>3</sup> were used to show distance. Together they make up what henceforth will be called ring-sectors, and all

<sup>3</sup> Although Zero Milestone was not the exact center of the CBD, it was chosen for use in this study because it had been employed in an earlier study *Travel to Commercial Centers of the Washington Metropolitan Area*, by Gordon B. Sharpe, Highway Research Board Bulletin 79, 1953.

<sup>1</sup> This article was presented at the 38th Annual Meeting of the Highway Research Board, Washington, D.C., January 1959.

<sup>2</sup> The procedures used in these studies are described in the *Manual of Procedures for Home Interview Traffic Study*, which is available by purchase from the Public Administration Service [1313 East 60th Street, Chicago, Ill.

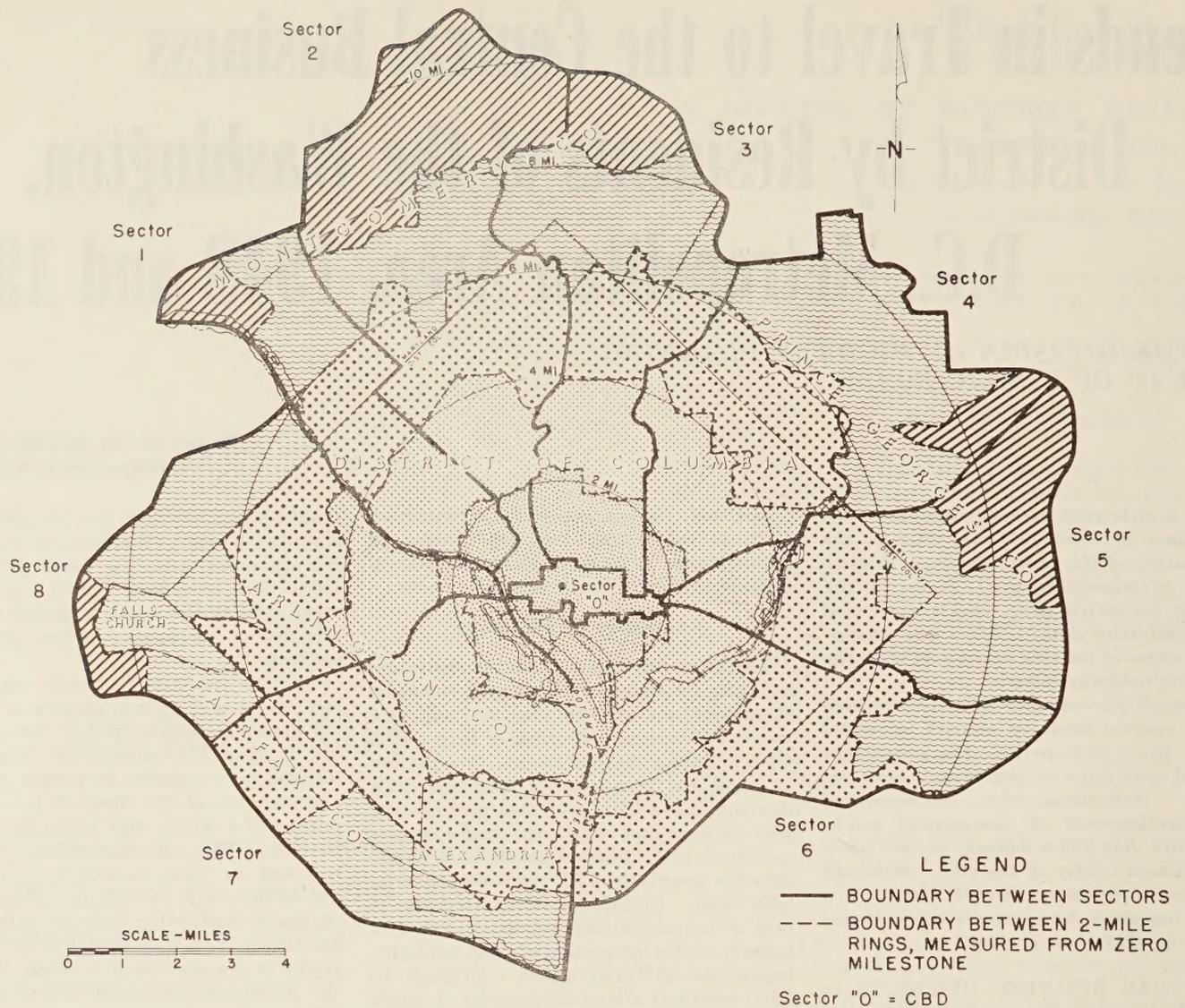


Figure 1.—Area of 1948 Washington, D.C., metropolitan transportation study, subdivided by ring-sectors.

trip data were grouped into these subdivisions. Ring-sectors are comprised of a number of transportation zones grouped according to the distance from the CBD of each zone's 1948 centroid of population. Because of the location of the centroids of population and the irregular shapes of transportation zones, the stippled areas in figure 1 tend to overlap the distance rings.

The area of the repeat study in 1955 was extended beyond the 1948 limits because of the growth in residential development. To have comparable data for a trend analysis, however, only those trips by persons residing within the 1948 area were used. This procedure did not bias the 1955 data to any great extent since the 1948 area included residents who made 92 percent of the trips within the 1955 cordon and 95 percent of the residents trips destined to the CBD.

The Washington CBD, as defined in this analysis, is shown in figure 2. Trips to this area, included in the study, were average weekday trips related to the traveler's zone of residence, even though the trips may have originated elsewhere. Although the trip zone of origin would provide a truer picture of direc-

tion and distance of actual travel to the CBD, experience in sampling has shown that place of residence and distribution of population are more stable and reliable factors when determining travel characteristics, both for the purpose of estimating future travel patterns to the CBD and for comparing travel patterns in two or more cities.

The trip purposes studied were limited to three groups: work, shop, and other. The category of "other" included business, medical-dental, school, social-recreation, eat meal, change mode of travel, serve passenger, and home trips.

There were several reasons for this grouping of trip purposes: first, for purposes of analysis, it was simpler; second, trips to work and to shop are the purposes most closely associated with trips to the CBD; and third, residents making trips for each of the reasons grouped in the "other" category made less than 20 percent of such trips to the CBD on an average weekday.

The modes of travel analyzed included automobile driver, automobile passenger, taxi passenger, and mass-transit passenger. Trips by taxi and truck operators in the course of

their daily work and all pedestrian travel were excluded. Pedestrian trips, however, must be kept in mind in any discussion of data concerning trips coming from within the first 2-mile ring.

### Characteristics of Study Area

Though there were changes within the Washington CBD, such as buildings demolished, parking facilities created, new office buildings erected, etc., the basic physical outline did not change greatly between 1948 and 1955, and it continued to have the commercial and employment functions associated with this complex type of land use. In addition, the CBD also houses many Federal Government activities, which are a major source of employment for area residents.

The number of persons employed in the CBD remained almost constant, increasing less than 2 percent between 1948 and 1955 (189,100 to 192,800 persons employed).

<sup>4</sup> Data concerning employment, income, and retail sales were obtained from selected statistics prepared by the transportation staff of the National Capital Planning Commission and the National Capital Regional Planning Council.

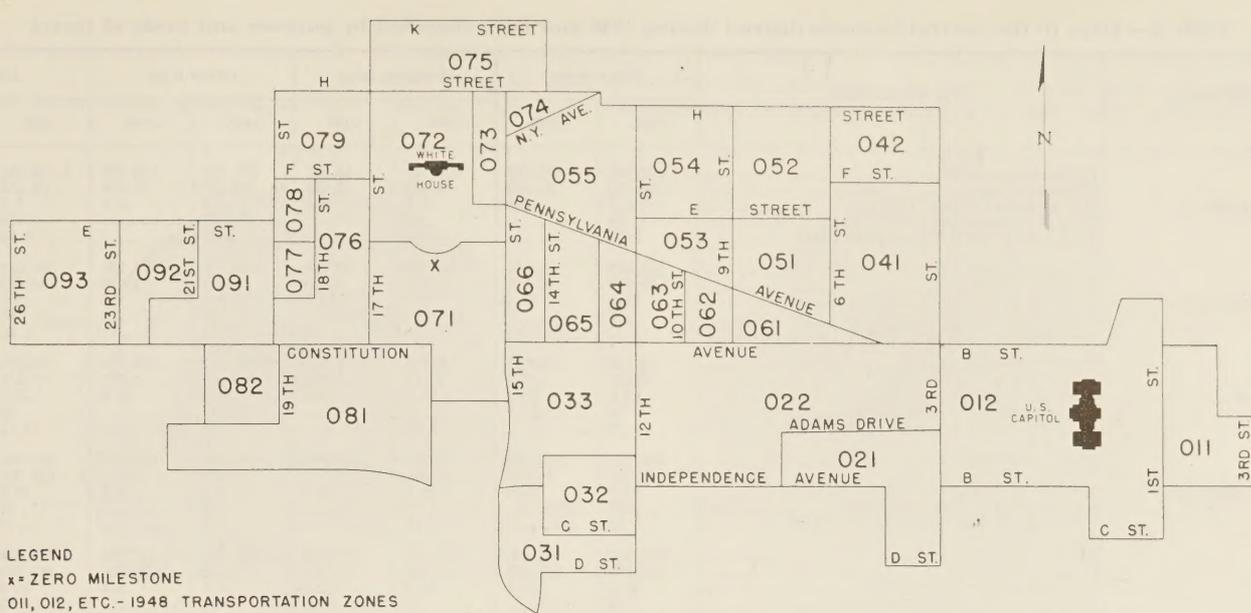


Figure 2.—Central business district of Washington, D.C.

Employment opportunities, however, had increased outside the CBD at a greater rate than within. The proportion within the CBD decreased from 31 to 27 percent, or from a ratio of 1 job for every 6 persons to 1 for every 8 persons living in the area.

Retail sales within the CBD remained approximately the same, about \$367 million for each of the 2 years. This is not a true comparison, however, when considering the changed value of the dollar. It was found that prices in 1955 had increased generally by 11.4 percent over 1948. When adjusted by the Consumer Price Index for metropolitan Washington as published by the Bureau of Labor Statistics, 1955 retail sales amounted to \$325 million, or a relative loss of 11 percent, as measured in 1948 dollars. Moreover, even though retail sales for the metropolitan area increased, the proportion of these sales made within the CBD, on a constant dollar basis, decreased from 26 to 19 percent.

Since the close of World War II, population growth in the Washington, D.C., area

has followed the general trend of most large metropolitan areas in the United States. Between 1948 and 1955, population within the area, as determined by the travel studies, increased 31 percent, from 1,110,000 to 1,454,000 persons (table 1). Approximately 95 percent of this growth occurred beyond 4 miles of the CBD.

A comparison of the percentage distribution of population and dwelling units between 1948 and 1955 reveals that the more significant relative changes occurred between the 2-mile distance rings rather than between sectors around the CBD. The relative distribution of population had changed between rings by as much as 6 percentage points from what it had been in 1948, while 7 of the 9 sectors changed less than 1 percentage point (table 1). Population growth was extending outward from the CBD with no major shifting of residents from one sector of the study area to another. The distribution of dwelling units followed the same general pattern as population.

### ANALYSIS OF DISTANCE AND DIRECTION FACTORS

The volume of intra-area travel by residents in 1955 increased 42 percent over what it had been in 1948 (table 2). Trips to the CBD, on the other hand, increased only 4 percent, or from 255,338 to 265,659. In addition, residential (dwelling unit) growth had increased 44 percent (336,181 to 485,108), or at a rate slightly greater than trip growth (table 1). While this resulted in a less than 2-percent decrease in total area trips per dwelling unit, trips per 100 dwelling units destined to the CBD decreased 28 percent (76 to 55).

Of greatest significance was the decrease in the proportion of trips destined to the CBD. Although there was a 4-percent increase in the actual volume, the percentage relationship of these trips to total area travel had decreased from 14.9 to 10.9 percent which presents a picture of decreasing trip orientation to the CBD.

Since this study involves measurement of the effects of distance and direction from the central area on the travel patterns to the CBD, an analysis was made to determine the "degree of trip orientation" to the CBD of the trips made by residents of each ring-sector. This was accomplished by comparing the percentage of residents trips for each ring-sector destined to the CBD with the average percentage for the total area. Residents of ring-sectors whose percentage of trips to the CBD exceeded the average for the total area could be said to have a greater than total area average orientation to the CBD. On the other hand, residents of those ring-sectors having a percentage of trips to the CBD below the average would be considered less oriented than the area as a whole. The percentages were then ranked in class intervals of 0 to 20, 20 to 40, and 40 percent or more above or below the total area average for each of the 2 years. Figure 3 illustrates the relative orientation of trips to the CBD by residents of each ring-sector in the manner just described.

The degree of trip orientation was then com-

Table 1.—Population, dwelling-unit, and density data for 1948 and 1955, grouped by rings and by sectors surrounding the central business district

Area	Population				Dwelling units				Number of dwelling units per residential acre, 1955 <sup>1</sup>
	1955		1948		1955		1948		
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	
<b>Rings:</b>									
0-2 miles.....	268,256	18.4	271,468	24.5	105,494	21.8	89,357	26.5	65.7
2-4 miles.....	379,293	26.1	354,912	32.0	137,610	28.3	108,491	32.4	22.3
4-6 miles.....	433,848	29.8	305,163	27.5	134,789	27.8	86,120	25.6	10.2
6-8 miles.....	284,938	19.6	145,627	13.1	83,039	17.1	42,556	12.7	6.5
8-10 miles.....	88,102	6.1	32,681	2.9	24,176	5.0	9,657	2.8	4.7
Total area.....	1,454,437	100.0	1,109,851	100.0	485,108	100.0	336,181	100.0	12.5
<b>Sectors:</b>									
0.....	5,910	0.4	6,291	0.6	3,323	0.7	2,767	0.8	195.5
1.....	57,565	4.1	43,146	3.9	22,267	4.6	13,205	4.0	7.8
2.....	173,748	12.0	129,236	11.7	67,256	13.9	44,715	13.3	9.9
3.....	367,558	25.3	321,147	29.1	128,400	26.5	98,476	29.3	21.5
4.....	212,025	14.5	153,803	13.7	63,672	13.1	42,927	12.6	13.8
5.....	150,466	10.4	107,168	9.6	41,816	8.6	27,704	8.3	16.7
6.....	210,034	14.3	157,408	14.2	66,642	13.7	44,163	13.1	20.6
7.....	149,753	10.3	115,869	10.4	51,923	10.7	40,016	11.9	9.9
8.....	127,378	8.7	75,783	6.8	39,809	8.2	22,208	6.7	5.1
Total area.....	1,454,437	100.0	1,109,851	100.0	485,108	100.0	336,181	100.0	12.5

<sup>1</sup> No comparable data available for 1948.

**Table 2.—Trips to the central business district during 1948 and 1955, classified by purpose and mode of travel**

Mode of travel	Trip comparisons	Work trips		Shopping trips		Other trips		All trips	
		1955	1948	1955	1948	1955	1948	1955	1948
Automobile driver	Total intra-area trips	272,097	164,109	108,458	45,847	777,700	418,824	1,158,255	628,780
	Trips to CBD	42,189	31,545	5,944	3,828	34,207	21,108	82,340	56,481
	Percentage of trips to CBD	15.5	19.2	5.5	8.3	4.4	5.0	7.1	9.0
	1955 percentage/1948 percentage	.81	-----	.66	-----	.68	-----	.79	-----
	1955 trips to CBD/1948 trips to CBD	1.34	-----	1.55	-----	1.62	-----	1.46	-----
Automobile passenger	Total intra-area trips	105,879	59,065	51,020	22,793	434,116	274,285	591,015	356,143
	Trips to CBD	33,419	19,125	4,472	3,581	12,552	12,010	50,443	34,716
	Percentage of trips to CBD	31.6	32.4	8.8	15.7	2.9	4.4	8.5	9.7
	1955 percentage/1948 percentage	.98	-----	.56	-----	.66	-----	.88	-----
	1955 trips to CBD/1948 trips to CBD	1.75	-----	1.25	-----	1.05	-----	1.45	-----
Taxi passenger	Total intra-area trips	13,550	10,017	2,974	1,901	41,572	34,558	58,096	46,476
	Trips to CBD	7,043	5,653	1,578	1,319	4,250	4,601	12,871	11,573
	Percentage of trips to CBD	52.0	56.4	53.1	69.4	10.2	13.3	22.2	24.9
	1955 percentage/1948 percentage	.92	-----	.77	-----	.77	-----	.89	-----
	1955 trips to CBD/1948 trips to CBD	1.25	-----	1.20	-----	.92	-----	1.11	-----
Mass-transit passenger	Total intra-area trips	183,857	219,003	29,765	39,619	408,060	419,576	621,682	678,198
	Trips to CBD	79,441	94,543	19,241	25,683	21,323	32,342	120,005	152,568
	Percentage of trips to CBD	43.2	43.2	64.6	64.8	5.2	7.7	19.3	22.5
	1955 percentage/1948 percentage	1.00	-----	1.00	-----	.68	-----	.86	-----
	1955 trips to CBD/1948 trips to CBD	.84	-----	.75	-----	.66	-----	.79	-----
All modes	Total intra-area trips	575,383	452,194	192,217	110,160	1,661,448	1,147,243	2,429,048	1,709,597
	Trips to CBD	162,092	150,866	31,235	34,411	72,332	70,061	265,659	255,338
	Percentage of trips to CBD	28.2	33.4	16.2	31.2	4.4	6.1	10.9	14.9
	1955 percentage/1948 percentage	.84	-----	.52	-----	.72	-----	.73	-----
	1955 trips to CBD/1948 trips to CBD	1.07	-----	.91	-----	1.03	-----	1.04	-----

pared for the 2 years to ascertain whether the general relationship of trips to the CBD had been maintained even though the percentage had decreased. In both years there were definite geographic areas which maintained a high degree of trip orientation. Residents who had a higher than average orientation in 1948, with few exceptions, retained this relative rank in 1955. Moreover, there were instances where the percentage of trips to the CBD decreased at a rate much less than that which was indicated by the average for the total area. As a result, these residents trips ranked even higher in relative orientation than they had in 1948. An example of this situation occurred in sectors 1, 2, and 3 (fig. 3).

**Trip Purposes**

The volume of residents intra-area work trips in 1955 increased 27 percent over that of 1948 (452,194 to 575,383). Work trips to the CBD, however, increased only 7 percent, from 150,866 to 162,092 (table 2). As a result, the percentage of work trips destined to the CBD decreased from 33.4 to 28.2 percent, or a 1955 to 1948 change ratio of 0.84. Although the CBD work trips decreased in relative importance since 1948, they had not decreased as much as shopping trips which had a change ratio of 0.52 or as much as "other" trips which had a change ratio of 0.72.

In each of the purpose categories, the proportion of CBD trips by mass transit decreased while trips by automobile increased (table 3). In actual volume, work trips by mass transit decreased from 94,543 to 79,441 (table 2). However, the 1955 to 1948 change ratio indicated that mass-transit work trips had an index of 1.00. The decreasing use of mass transit for travel to work was a general trend throughout the study area and not particularly characteristic of only the work trips to the CBD. This same characteristic applied to shopping trips to the CBD by mass transit.

The increasing proportion of work trips to the CBD by automobile passengers indicated a greater use of car pools. In the Washington

study area, mounting congestion, increased costs in driving and parking, and less convenient transit service in suburban areas have done much to encourage the forming of car pools by residents who must travel to the CBD day after day.

The volume of shopping trips within the study area increased 74 percent between 1948 and 1955 (110,160 to 192,217 trips). In contrast, the number destined to the CBD decreased 9 percent from 34,411 to 31,235 trips (table 2). This decrease in the number of CBD shopping trips was reflected in the relative decline in the dollar volume of retail sales discussed earlier.

This decline in the volume of CBD shopping trips, however, does not so vividly illustrate the decreased importance of the CBD for shopping as does the comparison between 1948 and 1955 of the percentage of total area shopping trips destined to the CBD (31 percent in 1948 and 16 percent in 1955). This sizable decrease reflects the increasing development as well as the attraction of commercial concentrations outside the CBD.

The CBD shopping trip ratio of automobile passengers to that of automobile drivers decreased from an average of 94 passengers in 1948 to 75 passengers for every 100 automobile drivers in 1955. This was in contrast to the trend for work trips which increased from an average of 61 automobile passengers in 1948 to 79 for every 100 automobile drivers in 1955.

From these comparisons there is an indication of a decrease in the number of family trips made to the CBD for shopping. The physical layout and the facilities offered in the outlying shopping centers were more conducive to family shopping than those located in the CBD.

Since trips classified as "other" include a wide range of purposes, any comparisons of 1948 and 1955 data should be qualified. "Other" trips to the CBD increased 3 percent in 1955 over what they had been in 1948 (70,061 to 72,332). Compared to the 45 percent increase in the total intra-area trip for this group (table 2), the increase in trips to the CBD was small.

As was also found for work and shopping trips, the proportion of "other" trips to the CBD had decreased relative to the total number of "other" residents trips. This comparison applies to an average of a group of purposes, and some purposes were above and some below this average.

Notable for "other" trips to the CBD was the comparatively large increase in the volume of automobile-driver trips (62 percent), whereas there was a comparatively slight increase in the volume of automobile-passenger trips (5 percent). As in shopping trips, group and family trips to the CBD compared with those made to other parts of the study area appeared to be relatively less, and those that were made by an individual (such as a visit

**Table 3.—Percentage distribution of trips to the central business district for various purposes in 1948 and 1955, classified by mode of travel**

Purpose of trip	Automobile-driver trips		Automobile-passenger trips		Taxi-passenger trips		Mass-transit passenger trips		All trips	
	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948
Work	26.0	20.9	20.6	12.7	4.4	3.7	49.0	62.7	100.0	100.0
Ratio, 1955/1948	1.24	-----	1.62	-----	1.19	-----	.78	-----	-----	-----
Shop	19.0	11.1	14.3	10.4	5.1	3.9	61.6	74.6	100.0	100.0
Ratio, 1955/1948	1.71	-----	1.38	-----	1.31	-----	.83	-----	-----	-----
Other	47.3	30.1	17.3	17.1	5.9	6.6	29.5	46.2	100.0	100.0
Ratio, 1955/1948	1.57	-----	1.01	-----	.89	-----	.64	-----	-----	-----
All purposes	31.0	22.1	19.0	13.6	4.8	4.5	45.2	59.8	100.0	100.0
Ratio, 1955/1948	1.40	-----	1.40	-----	1.07	-----	.76	-----	-----	-----

o a doctor or a business trip) were apparently increasing.

A separate geographical grouping of resi-

dents with a high degree of trip orientation was found for each of the three trip purposes studied (figs. 4-6). As indicated in figure 4,

the largest continuous area of residents with an above average work trip orientation was located in both study years within sectors 1.

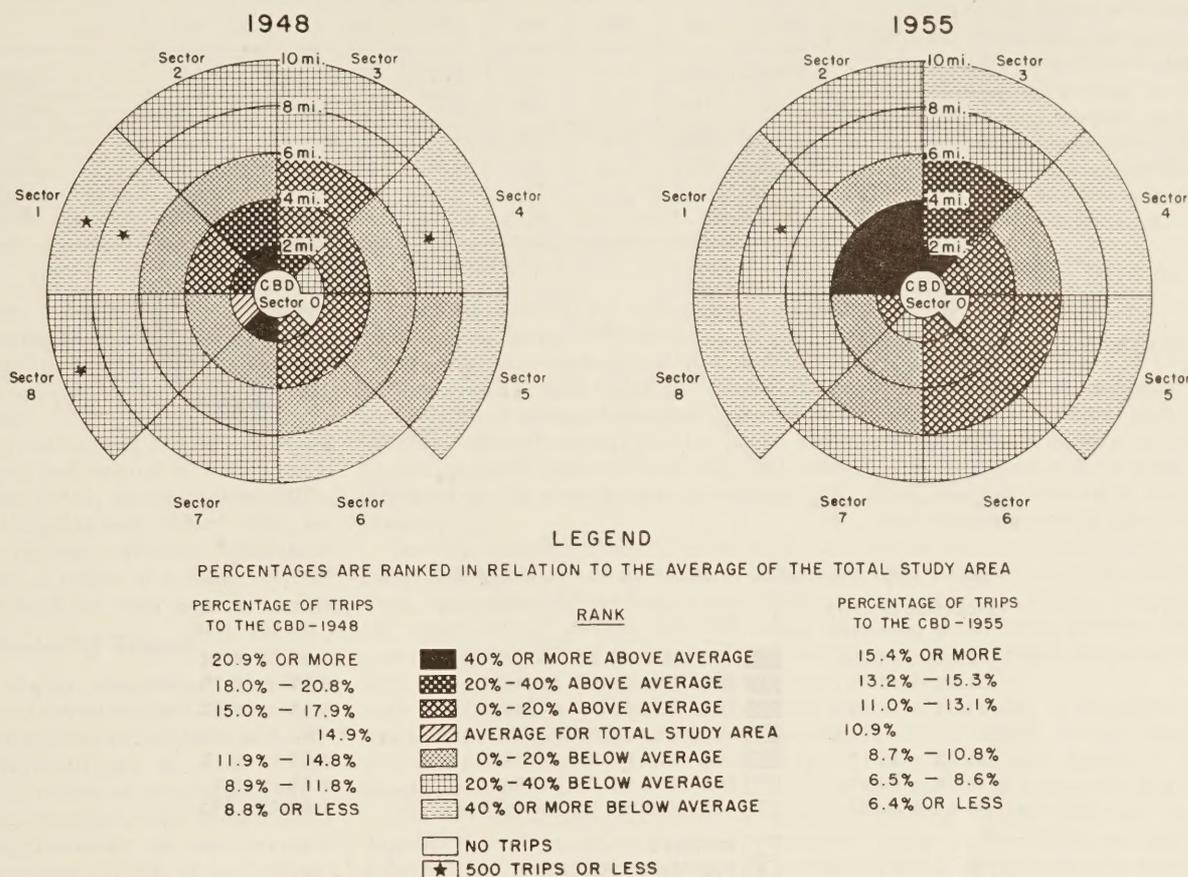


Figure 3.—Relation of CBD trips to total area trips for each ring-sector of residence.

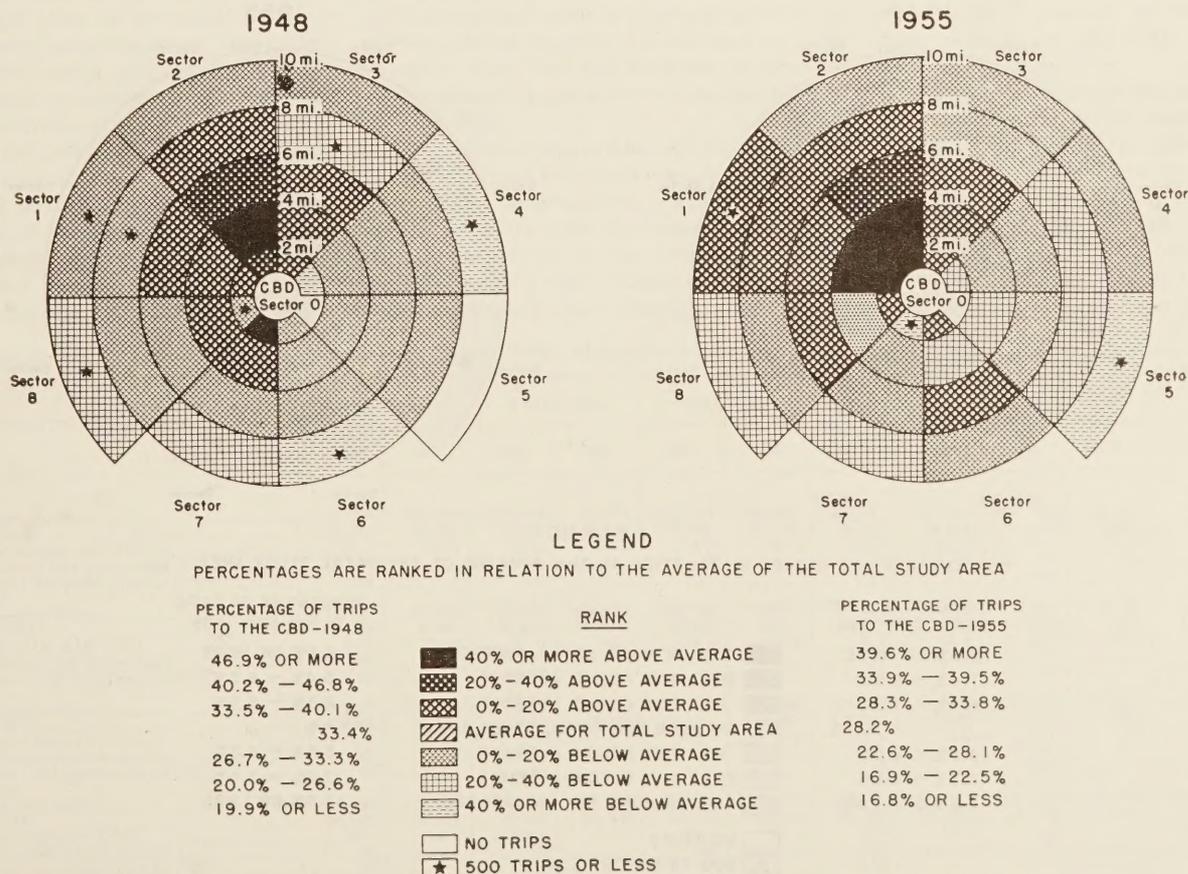


Figure 4.—Relation of CBD work trips to total area work trips for each ring-sector of residence.

2, and 3. On the other hand, figure 5 which shows the same information for shopping trips indicates that residents having an above average

age trip orientation for shopping were located within an entirely different geographical grouping. Hence, the degree of orientation varied

between trip purposes within any one ring sector.

Between 1948 and 1955 there was no major

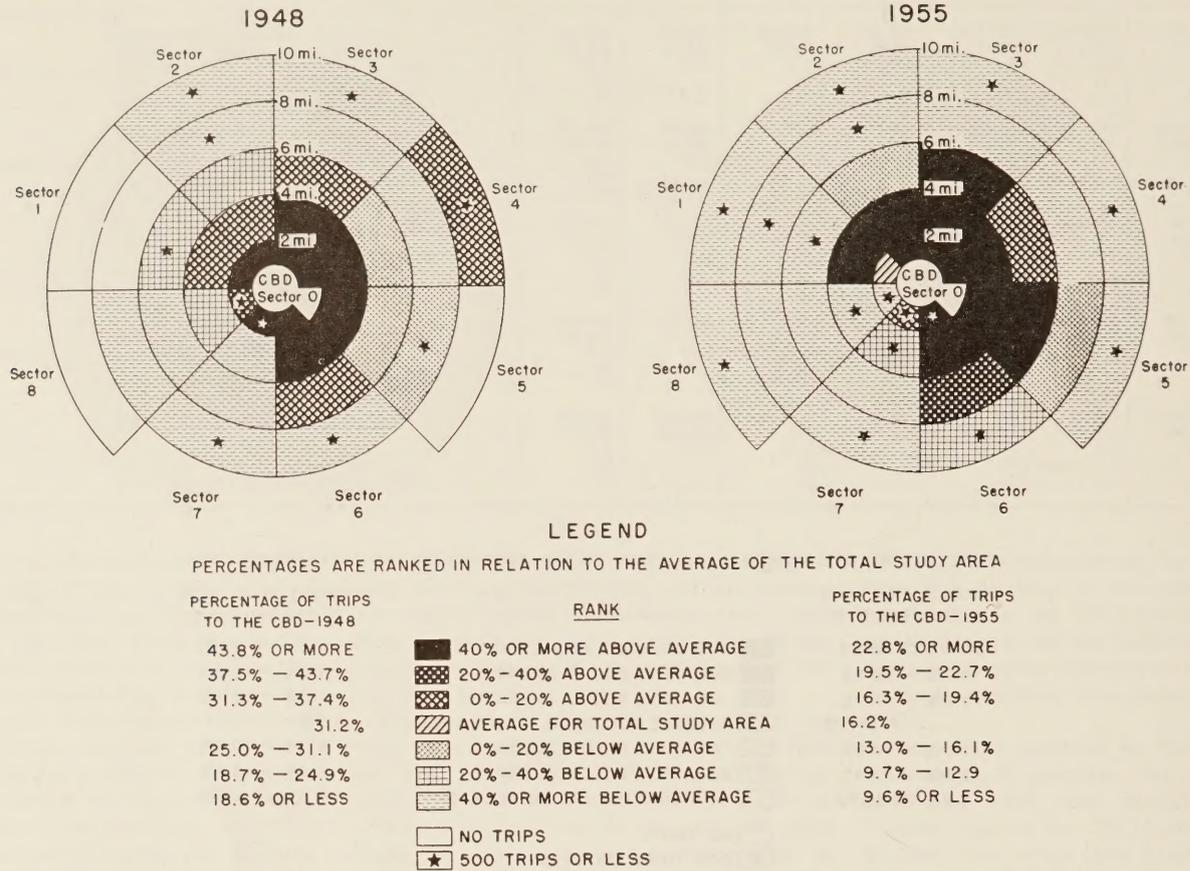


Figure 5.—Relation of CBD shopping trips to total area shopping trips for each ring-sector of residence.

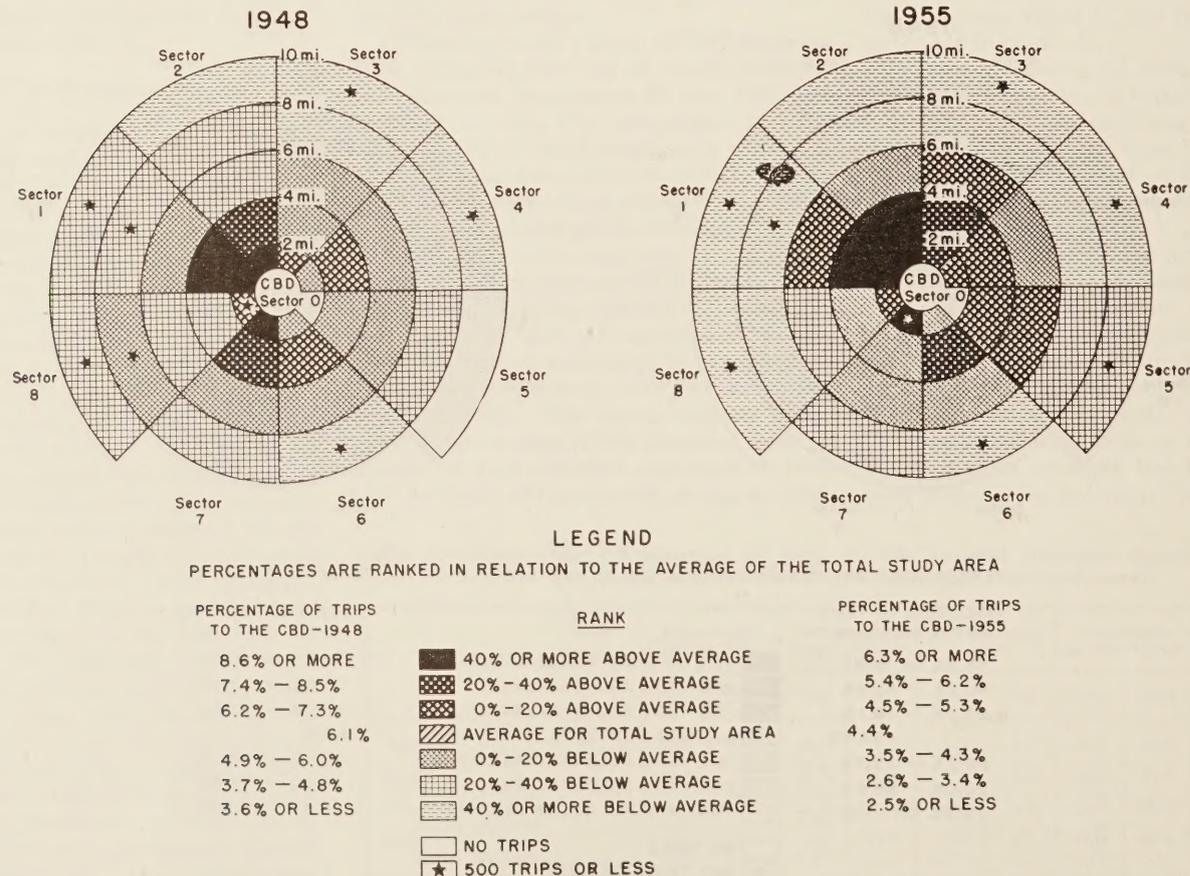


Figure 6.—Relation of "other" purpose CBD trips to total area "other" purpose trips for each ring-sector of residence.

**Table 4.—Percentage distribution of trips to the central business district by various modes of travel in 1948 and 1955, classified by purpose**

Mode of travel	Work trips		Shopping trips		Other trips		All trips	
	1955	1948	1955	1948	1955	1948	1955	1948
Automobile driver.....	51.2	55.9	7.2	6.8	41.6	37.3	100.0	100.0
Ratio, 1955/1948.....	.92	-----	1.06	-----	1.12	-----	-----	-----
Automobile passenger.....	96.2	55.1	8.9	10.3	24.9	34.6	100.0	100.0
Ratio, 1955/1948.....	1.20	-----	.86	-----	.72	-----	-----	-----
Taxi passenger.....	54.7	48.8	12.3	11.4	33.0	39.8	100.0	100.0
Ratio, 1955/1948.....	1.12	-----	1.08	-----	.83	-----	-----	-----
Mass-transit passenger.....	66.2	62.0	16.0	16.8	17.8	21.2	100.0	100.0
Ratio, 1955/1948.....	1.07	-----	.95	-----	.84	-----	-----	-----
All modes of travel.....	61.0	59.1	11.8	13.5	27.2	27.4	100.0	100.0
Ratio, 1955/1948.....	1.03	-----	.87	-----	.99	-----	-----	-----

shifting of these geographical groupings of above-average orientation from one part of the study area to another, even though the percentage of trips destined to the CBD decreased for each purpose. There were, however, extensions of the relative rank of above-average orientation which had existed in 1948 among residents in ring-sectors closer to the CBD. In the case of shopping and "other" trips, no radial pattern of above-average orientation extended beyond a radius of 6 miles in 1955 as was the case for work trips.

**Modes of Travel**

The major change observed in residents choice of mode of travel to the CBD was the increased use of private automobiles and conversely the decreased use of mass transit (table 3). The volume of automobile-driver and automobile-passenger trips to the CBD in 1955 had approximately the same percentage increase over that of 1948, 46 and 45 percent, respectively (table 2). As has been pointed out, the increased proportion of automobile-passenger trips in the work category offset the lesser proportions in the other categories. The overall average of the number of automobile passengers to the number of automobile drivers traveling to the CBD remained approximately the same, 61.5 automobile passengers to every 100 automobile drivers in 1948 and 61.3 in 1955.

The volume of taxi-passenger trips to the CBD by residents increased 11 percent, from 11,573 to 12,871 trips (table 2).

There was a decrease in the percentage of trips

destined to the CBD for each mode of travel. The mode of travel with the greatest relative change was automobile-driver trips, which had a change ratio of 0.79 (table 2). Even though the volume of automobile-driver trips to the CBD increased 46 percent over the period 1948 to 1955, trips to places outside the CBD had increased by an even greater percentage (88 percent).

The trip purposes for each travel mode indicate two significant characteristics (table 4). First, approximately one-half to two-thirds of the total volume of trips by each mode of travel in 1948 and 1955 were to work. Second, with the exception of automobile-driver trips, each of the modes of travel studied had a greater percentage of trips to work in 1955 and a smaller percentage for "other" purposes than was the case in 1948.

The increase in the percentage of automobile-driver trips made for "other" purposes reflects the increase in automobile ownership (61 cars per 100 dwelling units in 1948 and 79 in 1955). With the increased availability of an automobile as well as a general trend of an increase in the number of individuals licensed to drive, there was the tendency to drive to the luncheon engagement or to the night school in the CBD.

The degree of trip orientation that residents had in 1948 and 1955 indicated that there was a separate geographical grouping of ring-sector residents with above-average orientation for each of the modes used in traveling to the CBD (figs. 7-10). However, many of the radial patterns of above-average orientation, as

seen in 1948 for each mode, were not so apparent in 1955. Residents beyond 6 miles showed a greater tendency to have a lower degree of trip orientation to the CBD in 1955 for each of the modes of travel than they had in 1948. Thus, the general relationship (rank) between ring-sector residents and the CBD, as related to the average percentage for each mode of travel, changed and a geographical regrouping took place rather than an extension of the relative rank of orientation, as in purpose of trip. The pattern in 1955 appeared to be more of a readjustment of travel, linked possibly with the growth of new centers of attraction outside the CBD as well as increased automobile ownership.

**ANALYSIS OF DISTANCE FACTOR**

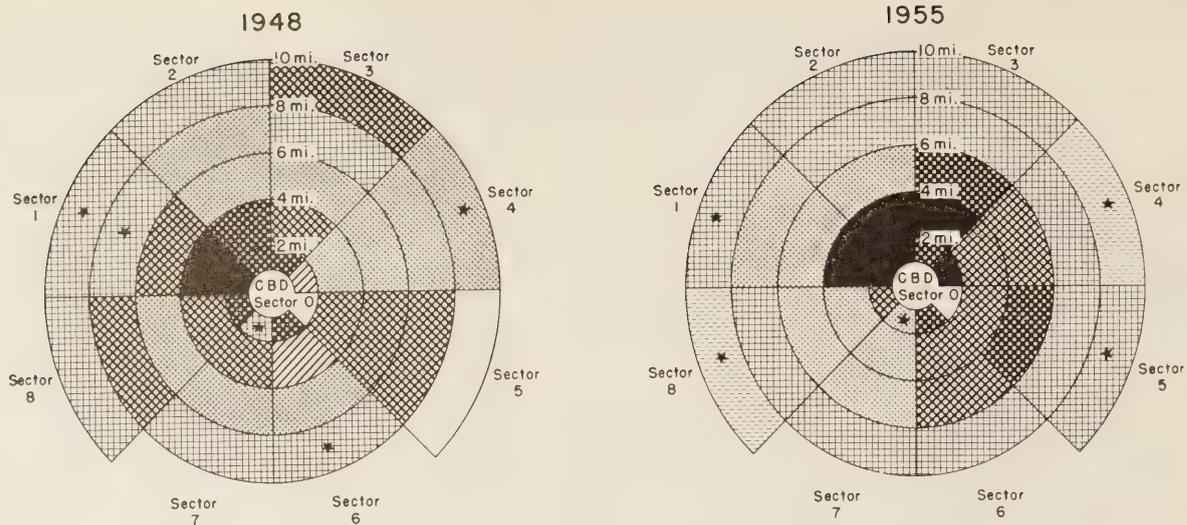
The attitude of residents concerning distances from the central part of the city may change, even in so short a period as 7 years. A travel distance of 10 miles to the CBD in 1955 was not considered unusual, whereas in 1948 residents would have felt that the distance was too great. This changed attitude did not develop simultaneously in all directions from the CBD. Therefore, the averages used in discussing distance ring characteristics vary to a certain extent between sectors of a ring.

In this study of the effects of distance upon residents travel, several changes of a significant nature are apparent. The first, as seen in table 5, is a decrease in the actual volume of trips to the CBD by residents within 4 miles of the CBD and an increase in the number of residents trips beyond this distance. Secondly, as brought out in table 5, there was a decrease of approximately the same magnitude, 3 percent, in the proportion of trips destined to the CBD by residents of each of the rings.

The pattern in which the percentage of trips destined to the CBD decreased was also significant (table 5). In 1955 the percentage for each of the first three distance rings was approximately the same as the percentage for the next outer ring in 1948. For example, in 1955, residents within 2 miles of the CBD made 16.5 percent of their total trips to the CBD; this was approximately the same per-

**Table 5.—Trips to the central business district in 1948 and 1955, classified according to purpose and distance of residence from the CBD**

Trip purpose comparisons	0 to 2 miles		2 to 4 miles		4 to 6 miles		6 to 8 miles		8 to 10 miles		Total area	
	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948
<b>Work trips:</b>												
Total intra-area trips.....	101,239	107,962	161,175	155,674	175,317	125,071	106,331	51,452	31,321	12,035	575,383	452,194
Trips to CBD.....	31,944	37,387	47,592	54,504	50,363	41,508	24,256	14,153	7,937	3,314	162,092	150,866
Percentage of trips to CBD.....	31.5	34.6	29.5	35.0	28.7	33.2	22.8	27.5	25.3	27.5	28.2	33.4
1955 percentage/1948 percentage.....	.91	-----	.84	-----	.86	-----	.83	-----	.92	-----	.84	-----
1955 trips to CBD/1948 trips to CBD.....	.85	-----	.87	-----	1.21	-----	1.71	-----	2.39	-----	1.07	-----
<b>Shopping trips:</b>												
Total intra-area trips.....	16,557	13,599	36,452	31,674	66,744	42,297	52,801	18,483	19,663	4,107	192,217	110,160
Trips to CBD.....	7,545	8,936	10,062	12,040	9,725	9,907	3,337	2,847	566	681	31,235	34,411
Percentage of trips to CBD.....	45.6	65.7	27.6	38.0	14.6	23.4	6.3	15.4	2.9	16.6	16.2	31.2
1955 percentage/1948 percentage.....	.69	-----	.73	-----	.62	-----	.41	-----	.17	-----	.52	-----
1955 trips to CBD/1948 trips to CBD.....	.84	-----	.84	-----	1.16	-----	1.17	-----	.83	-----	.91	-----
<b>Other trips:</b>												
Total intra-area trips.....	226,002	218,085	397,988	376,868	532,231	366,204	377,624	152,482	127,603	33,604	1,661,448	1,147,243
Trips to CBD.....	17,313	19,751	21,914	25,394	21,461	18,467	8,912	5,586	2,732	803	72,332	70,061
Percentage of trips to CBD.....	7.7	9.1	5.5	6.7	4.0	5.0	2.4	3.7	2.1	2.6	4.4	6.1
1955 percentage/1948 percentage.....	.85	-----	.82	-----	.80	-----	.65	-----	.81	-----	.72	-----
1955 trips to CBD/1948 trips to CBD.....	.88	-----	.86	-----	1.16	-----	1.60	-----	3.17	-----	1.03	-----
<b>All purposes:</b>												
Total intra-area trips.....	343,798	339,646	595,615	564,216	774,292	533,572	536,756	222,417	178,587	49,746	2,429,048	1,709,597
Trips to CBD.....	56,802	66,074	79,568	91,938	81,549	69,882	36,505	22,586	11,235	4,858	265,659	255,338
Percentage of trips to CBD.....	16.5	19.5	13.4	16.3	10.5	13.1	6.8	10.2	6.3	9.8	10.9	14.9
1955 percentage/1948 percentage.....	.85	-----	.82	-----	.80	-----	.67	-----	.64	-----	.73	-----
1955 trips to CBD/1948 trips to CBD.....	.86	-----	.87	-----	1.17	-----	1.62	-----	2.31	-----	1.04	-----



**LEGEND**  
 PERCENTAGES ARE RANKED IN RELATION TO THE AVERAGE OF THE TOTAL STUDY AREA

PERCENTAGE OF TRIPS TO THE CBD-1948

- 12.7% OR MORE
- 10.9% - 12.6%
- 9.1% - 10.8%
- 9.0%
- 7.2% - 8.9%
- 5.4% - 7.1%
- 5.3% OR LESS

RANK

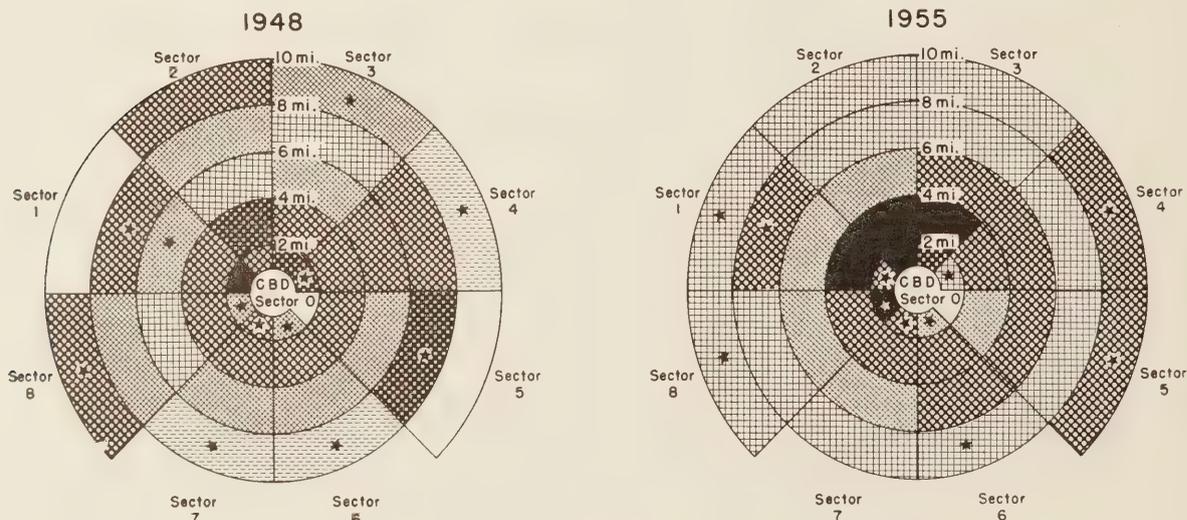
- 40% OR MORE ABOVE AVERAGE
- 20% - 40% ABOVE AVERAGE
- 0% - 20% ABOVE AVERAGE
- AVERAGE FOR TOTAL STUDY AREA
- 0% - 20% BELOW AVERAGE
- 20% - 40% BELOW AVERAGE
- 40% OR MORE BELOW AVERAGE

PERCENTAGE OF TRIPS TO THE CBD-1955

- 10.0% OR MORE
- 8.6% - 9.9%
- 7.2% - 8.5%
- 7.1%
- 5.7% - 7.0%
- 4.3% - 5.6%
- 4.2% - OR LESS

- NO TRIPS
- ★ 500 TRIPS OR LESS

*Figure 7.—Relation of CBD automobile-driver trips to total area automobile-driver trips for each ring-sector of residence.*



**LEGEND**  
 PERCENTAGES ARE RANKED IN RELATION TO THE AVERAGE OF THE TOTAL STUDY AREA

PERCENTAGE OF TRIPS TO THE CBD-1948

- 13.8% OR MORE
- 11.9% - 13.7%
- 9.9% - 11.8%
- 9.8%
- 7.8% - 9.7%
- 5.9% - 7.7%
- 5.8% OR LESS

RANK

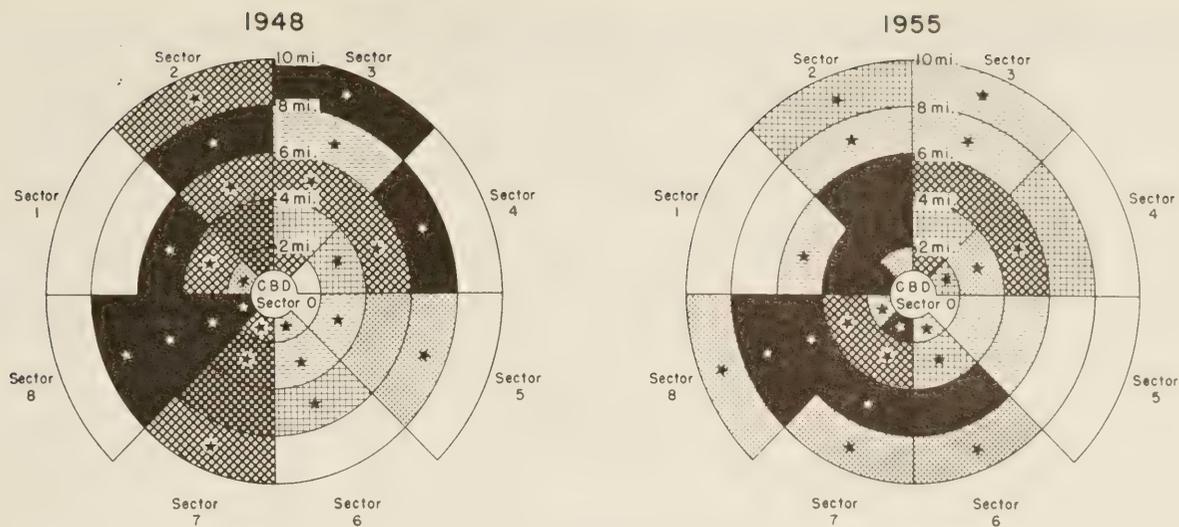
- 40% OR MORE ABOVE AVERAGE
- 20% - 40% ABOVE AVERAGE
- 0% - 20% ABOVE AVERAGE
- AVERAGE FOR TOTAL STUDY AREA
- 0% - 20% BELOW AVERAGE
- 20% - 40% BELOW AVERAGE
- 40% OR MORE BELOW AVERAGE

PERCENTAGE OF TRIPS TO THE CBD-1955

- 12.0% OR MORE
- 10.3% - 11.9%
- 8.6% - 10.2%
- 8.5%
- 6.8% - 8.4%
- 5.1% - 6.7%
- 5.0% OR LESS

- NO TRIPS
- ★ 500 TRIPS OR LESS

*Figure 8.—Relation of CBD automobile-passenger trips to total area automobile-passenger trips for each ring-sector of residence.*



LEGEND

PERCENTAGES ARE RANKED IN RELATION TO THE AVERAGE OF THE TOTAL STUDY AREA

PERCENTAGE OF TRIPS TO THE CBD-1948

- 35.0% OR MORE
- 30.0% - 34.9%
- 25.0% - 29.9%
- 24.9%
- 19.9% - 24.8%
- 14.9% - 19.8%
- 14.8% OR LESS

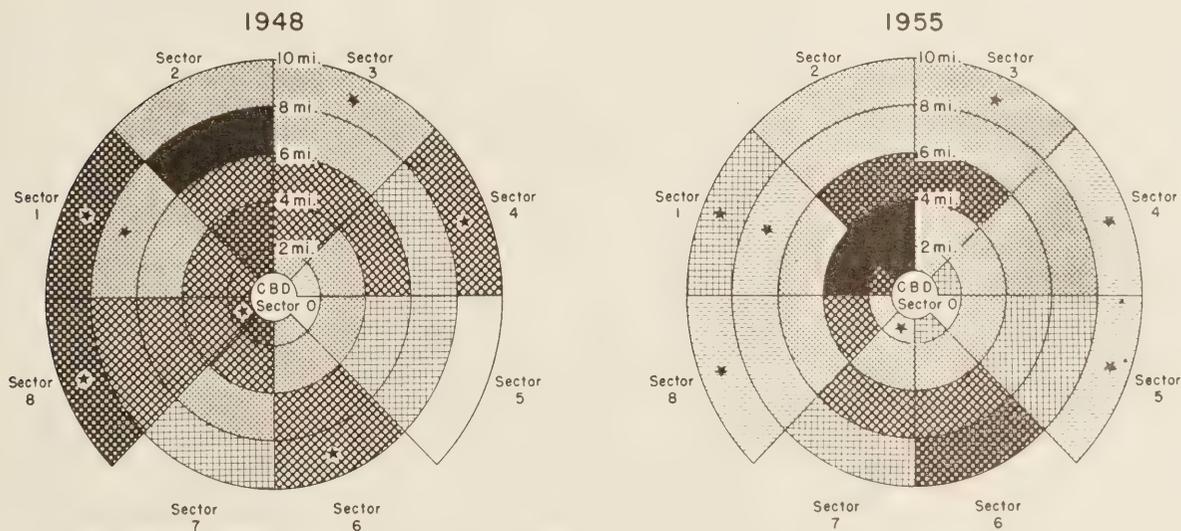
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- 40% OR MORE ABOVE AVERAGE
- 20% - 40% ABOVE AVERAGE
- 0% - 20% ABOVE AVERAGE
- AVERAGE FOR TOTAL STUDY AREA
- 0% - 20% BELOW AVERAGE
- 20% - 40% BELOW AVERAGE
- 40% OR MORE BELOW AVERAGE
- NO TRIPS
- ★ 500 TRIPS OR LESS

PERCENTAGE OF TRIPS TO THE CBD-1955

- 31.2% OR MORE
- 26.7% - 31.1%
- 22.3% - 26.6%
- 22.2%
- 17.8% - 22.1%
- 13.3% - 17.7%
- 13.2% OR LESS

Figure 9.—Relation of CBD taxi-passenger trips to total area taxi-passenger trips for each ring-sector of residence.



LEGEND

PERCENTAGES ARE RANKED IN RELATION TO THE AVERAGE OF THE TOTAL STUDY AREA

PERCENTAGE OF TRIPS TO THE CBD-1948

- 31.6% OR MORE
- 27.1% - 31.5%
- 22.6% - 27.0%
- 22.5%
- 18.0% - 22.4%
- 13.5% - 17.9%
- 13.4% OR LESS

RANK

- 40% OR MORE ABOVE AVERAGE
- 20% - 40% ABOVE AVERAGE
- 0% - 20% ABOVE AVERAGE
- AVERAGE FOR TOTAL STUDY AREA
- 0% - 20% BELOW AVERAGE
- 20% - 40% BELOW AVERAGE
- 40% OR MORE BELOW AVERAGE
- NO TRIPS
- ★ 500 TRIPS OR LESS

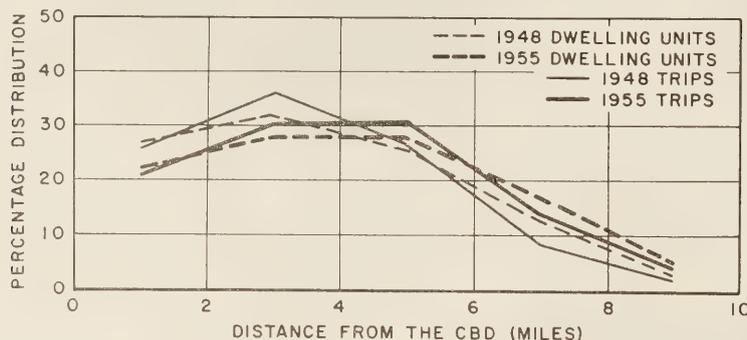
PERCENTAGE OF TRIPS TO THE CBD-1955

- 27.1% OR MORE
- 23.3% - 27.0%
- 19.4% - 23.2%
- 19.3%
- 15.4% - 19.2%
- 11.6% - 15.3%
- 11.5% OR LESS

Figure 10.—Relation of CBD mass-transit passenger trips to total area mass-transit passenger trips for each ring-sector of residence.

**Table 6.—Percentage distribution of trips to the central business district in 1948 and 1955, classified according to purpose and distance of residence from the CBD**

Distances from CBD	Work trips		Shopping trips		Other trips		All purposes	
	1955	1948	1955	1948	1955	1948	1955	1948
0-2 miles	19.7	24.8	24.2	26.0	23.9	28.2	21.4	25.9
2-4 miles	29.3	36.1	32.2	35.0	30.3	36.2	30.0	36.0
4-6 miles	31.1	27.5	31.1	28.7	29.7	26.4	30.7	27.4
6-8 miles	15.0	9.4	10.7	8.3	12.3	8.0	13.7	8.8
8-10 miles	4.9	2.2	1.8	2.0	3.8	1.2	4.2	1.9
Total area	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0



**Figure 11.—Percentage distribution of residents' CBD trips and dwelling units, according to distance from the CBD.**

centage as for residents within 2 to 4 miles of the CBD in 1948. If this trend were to continue for the following 7 years, the residents within 2 miles of the CBD in 1962 would make approximately the same percentage of trips to the CBD as residents 2 to 4 miles from the CBD made in 1955, or 13 percent; residents 2 to 4 miles and 4 to 6 miles from the CBD would make 10 and 6 percent, respectively, of their trips to the CBD in 1962.

The percentage of trips to the CBD by residents 6 to 8 and 8 to 10 miles from the CBD did not fit the pattern of change just described. The percentage for both rings was approximately the same in each year. This similarity in the two outer rings, which are basically suburban, suggests that residents of suburban areas tend to have a more similar orientation to the CBD than urban areas closer to the CBD.

A significant factor in the distribution by distance of residents' CBD trips was the leveling off which occurred between 2 to 4 miles and 4 to 6 miles of the CBD (table 6 and figure 11), a characteristic also observed in the distribution of dwelling units. In 1948, the major proportion of trips to the CBD were made by residents within 2 to 4 miles of the CBD. At that time, residents of this ring accounted for 91,938 or 36 percent of the total trips to the CBD. In 1955, however, the number of CBD trips made by residents within 2 to 4 miles had decreased and similar trips made by residents within 4 to 6 miles had increased. As a result, the number of trips from the two rings were about the same, 79,568 and 81,549, respectively.

This characteristic of residents' trips to the CBD is important in estimating future trip distribution. Theoretically, it is altogether possible that total trips to the CBD made by residents of each of the five distance rings could approach, although not reach, a more uniform distribution. Over a period of time

the level of trip distribution found between the 2- to 4- and 4- to 6-mile rings would just extend outward at a lower percentage level through the 6- to 8- and possibly the 8- to 10-mile rings. As the percentage of CBD trips by residents residing between 6 and 10 miles of the CBD increases, there will be a relative decrease in the percentage of the total CBD trips made by residents within 6 miles of the CBD.

Two observations support this possible trend in residents' trip distribution. The first was the greater uniformity in the number of CBD trips per 100 dwelling units throughout the five distance rings in 1955 (table 7); the range in the number of trips was from 44 to 61, or a difference of 17. In 1948, the range in the number of trips among distance rings was from 50 to 85, or a difference of 35.

The second observation has to do with the increase in the proportion of dwelling units located between 6 and 10 miles of the CBD (table 1). In 1948, this area contained 15.5 percent of the total dwelling units within the study area; by 1955, the proportion had increased to 22.1 percent. Each consecutive ring circumscribed a much larger area than the preceding ring. Even though residential density per acre is progressively less as distance from the CBD increases, the larger area of each consecutive ring permits a

**Table 7.—Number of trips per 100 dwelling units to the central business district in 1948 and 1955, classified according to purpose and distance of residence from the CBD**

Distances from CBD	Work trips		Shopping trips		Other trips		All purposes	
	1955	1948	1955	1948	1955	1948	1955	1948
0-2 miles	30.3	41.8	7.2	10.0	16.4	22.1	53.8	73.9
2-4 miles	34.6	50.2	7.3	11.1	15.9	23.4	57.8	84.7
4-6 miles	37.4	48.2	7.2	11.5	15.9	23.4	60.5	81.1
6-8 miles	29.2	33.3	4.0	6.7	10.7	13.1	44.0	53.1
8-10 miles	32.8	34.3	2.3	7.1	11.3	8.9	46.5	50.3
Average, total area	33.4	44.9	6.4	10.2	14.9	20.8	54.8	76.0

corresponding increase in the number of residences within each ring when fully developed. This has occurred in the 2- to 4- and 4- to 6-mile distance rings. In 1955 the densities within these rings were 22.3 and 10.2 dwelling units per acre, respectively, but the total number of residences for the 2 rings were nearly equal, 137,610 and 134,789.

If there continues to be an increasing similarity in the frequency of CBD trips per 100 dwelling units, and if it is assumed that the residential development within 6 miles of the CBD will become more static as less land is available for new development, and the residential development between 6 and 10 miles of the CBD continues at a high rate of increase because of the open land available, then, theoretically, there would be a greater increase in the number of trips from the outer rings than from those closer to the city center. The percentage of total CBD trips by residents located between 6 and 10 miles of the CBD will increase, and this would cause a relative decrease in the proportion of total CBD trips made by residents within 6 miles of the CBD.

### Trip Purposes

Between 1948 and 1955, a change took place in the percentage distribution of residents' trip purposes that was related to distance from the CBD (table 8). In 1948 the proportion of residents' trips to the CBD for work increased with distance from the CBD. The reverse was true of "other" trips. The proportion of trips for shopping, however, varied only slightly with distance; the difference between the nearest ring and the farthest ring from the CBD was only 0.5 percent.

The pattern of trip distribution in 1955 remained about the same as 1948 for work and "other" trips. In contrast, the percentage of CBD trips for shopping decreased with distance, from 13.3 percent within 2 miles of the CBD to 5.0 percent within 8 to 10 miles of the CBD. This comparison shows the effect of increased commercial development outside the CBD, especially in the suburban communities.

### Work trips

In 1955 there was no concentration of residents making work trips to the CBD in any single concentric distance ring as was the case in 1948. As shown in table 6 for 1948, residents 2 to 4 miles from the CBD had made the largest proportion of the total work trips destined to the CBD (36.1 percent). By 1955, however, the percentage distribution had

changed, and there was only a 2-percent difference between the proportion of trips made by the residents within 2 to 4 and 4 to 6 miles of the CBD (29.3 and 31.1 percent, respectively). The changes that occurred during the 7-year period are illustrated graphically in figure 12. As work trips made up a major

portion of the total CBD trips, it is apparent that residents work trips were an important factor in the leveling of the distribution curve.

In the future an increasing percentage of CBD work trips is expected to be made by residents of the outer rings, extending the

plateau of percentage distribution at a lower percentage level over an even wider area than in 1955. As shown in table 7, the range among distance rings for work trips destined to the CBD per 100 dwelling units was only half as great in 1955 as it was in 1948. If this range of difference were to be maintained

**Table 8.—Percentage distribution of trips to the central business district in 1948 and 1955, classified according to trip purpose of mode traveled and distance of residence from the CBD**

Mode of travel and trip purpose	0 to 2 miles		2 to 4 miles		4 to 6 miles		6 to 8 miles		8 to 10 miles		Total area	
	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948
<b>Automobile-driver trips to—</b>												
Work	45.0	48.4	46.4	54.8	50.3	55.2	58.4	64.0	66.6	70.1	51.2	55.8
Ratio, 1955/1948	.93		.85		.91		.91		.95		.92	
Shop	3.8	6.5	8.7	5.9	8.2	7.4	7.4	6.9	2.1	9.2	7.2	6.8
Ratio, 1955/1948	.58		1.47		1.11		1.07		.23		1.06	
Other	51.2	45.1	44.9	39.3	41.5	37.4	34.2	29.1	31.3	20.7	41.6	37.4
Ratio, 1955/1948	1.14		1.14		1.11		1.18		1.51		1.11	
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<b>Automobile-passenger trips to—</b>												
Work	54.5	51.6	63.0	52.7	68.0	56.8	72.8	61.2	75.0	56.2	66.2	55.1
Ratio, 1955/1948	1.06		1.20		1.20		1.19		1.33		1.20	
Shop	12.0	6.1	8.7	10.3	9.4	11.7	7.3	9.6	5.3	20.1	8.9	10.3
Ratio, 1955/1948	1.97		.84		.80		.76		.26		.86	
Other	33.5	42.3	28.3	37.0	22.6	31.5	19.9	29.2	19.7	23.7	24.9	34.6
Ratio, 1955/1948	.79		.76		.72		.68		.83		.72	
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<b>Taxi-passenger trips to—</b>												
Work	56.1	51.3	56.8	47.1	50.1	48.7	57.7	30.7	33.5	87.7	54.7	48.8
Ratio, 1955/1948	1.09		1.21		1.03		1.88		.38		1.12	
Shop	9.1	10.4	11.6	10.4	18.8	14.1	11.6	17.3	8.4		12.3	11.4
Ratio, 1955/1948	.88		1.12		1.33		.67				1.08	
Other	34.8	38.3	31.6	42.5	31.1	37.2	30.7	52.0	58.1	12.3	33.0	39.8
Ratio, 1955/1948	.91		.74		.84		.59		4.72		.83	
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<b>Mass-transit passenger trips to—</b>												
Work	60.0	59.0	65.9	63.0	70.3	63.0	73.2	64.3	76.0	74.2	66.2	62.0
Ratio, 1955/1948	1.02		1.05		1.12		1.14		1.02		1.07	
Shop	17.0	15.9	16.1	16.3	16.1	18.5	13.4	18.4	11.1	17.7	16.0	16.8
Ratio, 1955/1948	1.07		.99		.87		.73		.63		.95	
Other	23.0	25.1	18.0	20.7	13.6	18.5	13.4	17.3	12.9	8.1	17.8	21.2
Ratio, 1955/1948	.92		.87		.74		.77		1.59		.84	
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<b>All modes of travel to—</b>												
Work	56.2	56.6	59.8	59.3	61.8	59.4	66.4	62.7	70.7	68.2	61.0	59.1
Ratio, 1955/1948	.99		1.01		1.04		1.06		1.04		1.03	
Shop	13.3	13.5	12.7	13.1	11.9	14.2	9.2	12.6	5.0	14.0	11.8	13.5
Ratio, 1955/1948	.99		.97		.84		.73		.36		.87	
Other	30.5	29.9	27.5	27.6	26.3	26.4	24.4	24.7	24.3	17.8	27.2	27.4
Ratio, 1955/1948	1.02		1.00		1.00		.99		1.37		.99	
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

**Table 9.—Percentage distribution of trips to the central business district in 1948 and 1955, classified according to mode of travel of trip purpose and distance of residence from the CBD**

Trip purpose and mode of travel	0 to 2 miles		2 to 4 miles		4 to 6 miles		6 to 8 miles		8 to 10 miles		Total area	
	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948
<b>Work trips by—</b>												
Automobile drivers	14.7	10.3	20.5	19.4	29.8	25.7	38.0	35.1	44.3	44.4	26.0	20.9
Ratio, 1955/1948	1.43		1.06		1.16		1.08		1.00		1.24	
Automobile passengers	11.7	7.7	17.7	11.7	22.8	15.2	29.3	20.1	33.4	21.4	20.6	12.7
Ratio, 1955/1948	1.52		1.51		1.50		1.46		1.56		1.62	
Taxi passengers	8.8	6.5	4.9	3.2	3.0	2.8	1.4	1.3	.7	4.5	4.4	3.7
Ratio, 1955/1948	1.35		1.53		1.07		1.08		.16		1.19	
Mass-transit passengers	64.8	75.5	56.9	65.7	44.4	56.3	31.3	43.5	21.6	29.7	49.0	62.7
Ratio, 1955/1948	.86		.87		.79		.72		.73		.78	
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<b>Shopping trips by—</b>												
Automobile drivers	5.3	5.8	18.1	9.5	25.1	14.5	35.2	18.9	20.0	28.2	19.0	11.1
Ratio, 1955/1948	.91		1.91		1.73		1.86		.71		1.71	
Automobile passengers	10.9	3.8	11.6	10.4	16.3	13.0	21.3	15.7	33.4	37.3	14.3	10.4
Ratio, 1955/1948	2.87		1.12		1.25		1.36		.90		1.38	
Taxi passengers	6.0	5.5	4.8	3.2	5.8	3.4	2.0	3.7	2.3		5.1	3.9
Ratio, 1955/1948	1.09		1.50		1.71		.54				1.31	
Mass-transit passengers	77.8	84.9	65.5	76.9	52.8	69.1	41.5	61.7	44.3	34.5	61.6	74.6
Ratio, 1955/1948	.92		.85		.76		.67		1.28		.83	
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<b>Other trips by—</b>												
Automobile drivers	30.8	18.2	43.0	29.9	57.8	39.2	60.6	40.4	60.5	50.4	47.3	30.1
Ratio, 1955/1948	1.69		1.44		1.47		1.50		1.20		1.57	
Automobile passengers	13.3	12.0	17.3	17.7	17.8	18.8	21.8	24.3	25.5	34.8	17.3	17.1
Ratio, 1955/1948	1.11		.98		.95		.90		.73		1.01	
Taxi passengers	10.1	9.1	6.0	6.2	4.3	4.8	2.0	5.8	3.3	2.4	5.9	6.6
Ratio, 1955/1948	1.10		.97		.90		.34		1.38		.89	
Mass-transit passengers	45.8	60.7	33.7	46.2	20.1	37.2	15.6	29.5	10.7	12.4	29.5	46.2
Ratio, 1955/1948	.75		.73		.54		.53		.86		.64	
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
<b>All purposes by—</b>												
Automobile drivers	18.4	12.0	26.4	21.0	36.6	27.7	43.2	34.4	47.0	43.2	31.0	22.1
Ratio, 1955/1948	1.53		1.26		1.32		1.26		1.09		1.40	
Automobile passengers	12.1	8.5	16.9	13.2	20.7	15.8	26.7	20.6	31.5	26.0	19.0	13.6
Ratio, 1955/1948	1.42		1.28		1.31		1.30		1.21		1.40	
Taxi passengers	8.8	7.1	5.1	4.0	3.7	3.4	1.6	2.7	1.4	3.5	4.8	4.5
Ratio, 1955/1948	1.24		1.28		1.09		.59		.40		1.07	
Mass-transit passengers	60.7	72.4	51.6	61.8	39.0	53.1	28.5	42.3	20.1	27.3	45.2	59.8
Ratio, 1955/1948	.84		.83		.73		.67		.74		.76	
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

or decreased even more, then those rings with the greatest future growth in residential development would tend to have the largest increases in residents work trips to the CBD.

On the basis of present day residential development, it is expected that the majority of future dwelling units will be constructed in the outer rings, thereby increasing the relative percentage of total work trips to the CBD from these areas. This is already apparent in the increased proportion of the total work trips made to the CBD by residents of the 6- to 8-mile ring. In 1948, residents of this ring made 9.4 percent of the CBD work trips as compared with 15.0 percent in 1955.

Although the volume of residents work trips destined to the CBD in 1955 decreased within 4 miles of the CBD and increased beyond this distance, the percentage made to the CBD by residents of each distance ring decreased (table 5). It should be noted also that trips made by residents within 2 miles and within 8 to 10 miles of the CBD had approximately the same change ratio, 0.91 and 0.92, respectively. Because of distance, it would be expected that a greater decrease in residents trips would be found in the 8- to 10-mile ring than in the area between 2 and 8 miles.

The explanation of this relationship was found by examining the trips made by residents of sector 2 of the 8- to 10-mile ring. Residents of this sector, as will be mentioned later, had an above-average orientation of intra-area work trips that were destined to the CBD. Residents of this ring-sector also accounted for over one-half of the trips made

by residents of this ring. Because of the small number of trips made by residents of the other sectors of this ring, residents of sector 2 greatly influenced the results for this ring. It is possible that as residential development increases in the other sectors of the 8- to 10-mile ring, that are less oriented to the CBD than sector 2, a change ratio more in line with the travel distance will occur.

Another change which took place during the 7-year period was the shift in mode of travel to work (table 9). For both years, the general pattern was for the percentages of automobile-driver and automobile-passenger work trips to increase with distance from the CBD while the percentages of work trips made by taxi passengers and mass-transit passengers decreased with distance. However, in 1955, the most significant difference was the decreasing distance in which mass transit was the dominant mode used to travel to work. In 1948 residents within 6 miles of the central area made 50 percent or more of their work trips to the CBD by mass transit. In 1955 this percentage applied to a 4-mile radius.

It should be noted that the percentage of residents work trips made by mass transit in 1955 for any given distance ring was approximately the same as the percentage in 1948 for the next outer ring. For example, in 1955, residents within 2 miles of the CBD made 64.8 percent of their work trips by mass transit; in 1948 residents within 2 to 4 miles made approximately the same percentage, 65.7. This same relationship follows re-

gardless of distance ring. If this same pattern were to continue in the 7 years following 1955, then by 1962 only the residents within 2 miles of the CBD would make over 50 percent of their work trips to the CBD by mass transit.

### Shopping trips

The percentage distribution of residents shopping trips to the CBD changed less between the five distance rings than the distribution of work or "other" trips, even though there was a decrease in the total volume of shopping trips to the CBD between 1948 and 1955. Of the relative changes that did take place, however, the most significant was the apparent leveling off of the peak of trip distribution within 2 to 4 miles of the CBD (fig. 12). Residents within 2 to 4 and 4 to 6 miles of the CBD in 1955 made 32.2 and 31.1 percent, respectively, of the shopping trips to the CBD (table 6).

In the previous discussion of work trips it was mentioned that with growth in residential development beyond 6 miles of the CBD, the leveling of the distribution curve would likely extend over an even wider area than in 1955, and this would result in a more uniform distribution of residents work trips to the CBD. In the case of shopping trips, however, there is no basis for such speculation.

Between 1948 and 1955 the average number of daily shopping trips to the CBD per 100 dwelling units decreased in each of the 2-mile rings, and the percentage decrease became progressively greater with distance from the central area (table 7). It is evident that residents, particularly those within the first three distance rings, were patronizing stores outside the CBD for many of their needs and relied on the CBD stores for shopping goods merchandise or for items where a greater selection was desired. In the case of the outlying communities (beyond 6 miles of the CBD), residents had ready access to major shopping areas which could supply practically all of their needs. Two department stores had a suburban branch in 1948, and these were relatively small in sales floor area. By 1955, one or more branches had been established by each of the large department stores and by many of the large specialty stores.

In 1948 the area between 6 and 10 miles of the CBD contained approximately 52,200 dwelling units and accounted for a total of 22,600 intra-area shopping trips; of this number, 3,500 were made to the CBD. By 1955 the number of dwelling units had increased to 107,200 and intra-area shopping trips had increased to 72,500; yet, of these trips, only 3,900 were to the CBD. The percentage of intra-area shopping trips destined to the CBD decreased during the 7-year period from 15.6 to 5.4 percent, a change ratio of 0.35.

Of the changes in mode of travel, the most significant was the decreased distance from the CBD in which mass transit accounted for one-half or more of residents shopping trips to the CBD (table 9). In 1948 residents within 8 miles of the CBD used mass transit for more than half of their trips; in 1955, the

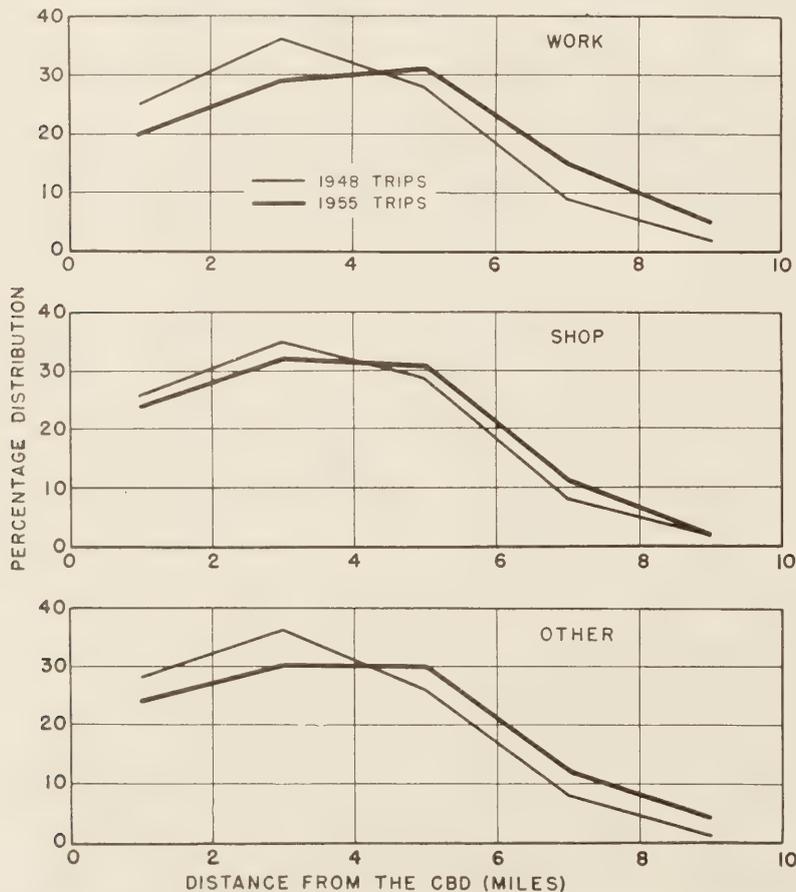


Figure 12.—Percentage distribution of work, shop, and other purpose trips to the CBD, according to distance from the CBD.

same ratio applied only to residents within miles.

Mass-transit passenger travel, although increasing in the relative percentage of total hopping trips destined to the CBD, nevertheless accounted for about three-fourths of all hopping trips made to the CBD by residents within a 2-mile radius and two-thirds of such trips by residents within 2 to 4 miles of the CBD. These high percentages were maintained because of the large number of well distributed, converging transit lines which provided the more densely populated rings

with convenient passenger service to the retail core of the CBD.

The only group to show an increase between 1948 and 1955 in the percentage of shopping trips by mass transit were residents of the 8- to 10-mile ring. This apparent inconsistency may be due to sample variability, as the total number of shopping trips to the downtown area by residents of this ring was relatively small, the calculated figure being 681 in 1948 and 566 in 1955. Since the sampling rate was 1 in 20 in this area in 1948 and 1 in 10 in 1955, the number of residents

interviewed was only 34 in the first year and 56 in the second year. When broken down by mode of travel, therefore, the reliability of the data on mode of travel for this ring is not great.

**Other purpose trips**

The volume of CBD trips made for purposes other than to work or shop by residents within a 4-mile radius of the CBD decreased between 1948 and 1955. Beyond 4 miles, however, there was an increase in the number of such trips. The distribution pattern followed closely that of work and shopping trips (table 6 and figure 12).

Because of the diverse purposes included in the "other" category, it is difficult to do any more than speculate on the future position of the distribution curve. As a group, however, these trip purposes had several of the trend characteristics observed in the distribution of work trips. First, the range between the ring with the largest and the one with the smallest number of "other" trips to the CBD per 100 dwelling units decreased from 14 trips in 1948 to 6 in 1955 (table 7), and secondly, residents beyond 6 miles were making an increasing proportion of total "other" trips to the CBD (table 6).

With increased residential development in the outer rings and decreasing differences between rings in trips per dwelling unit, the distribution curve over a period of time might be expected to parallel that of work trips. In any discussion of future trends, the several purpose categories that make up "other" trips must be considered. Trips for purposes of social-recreation, eat meal, and business are not quite so rigid in their directional movement, and there is greater opportunity for choice of destination than there is for work trips.

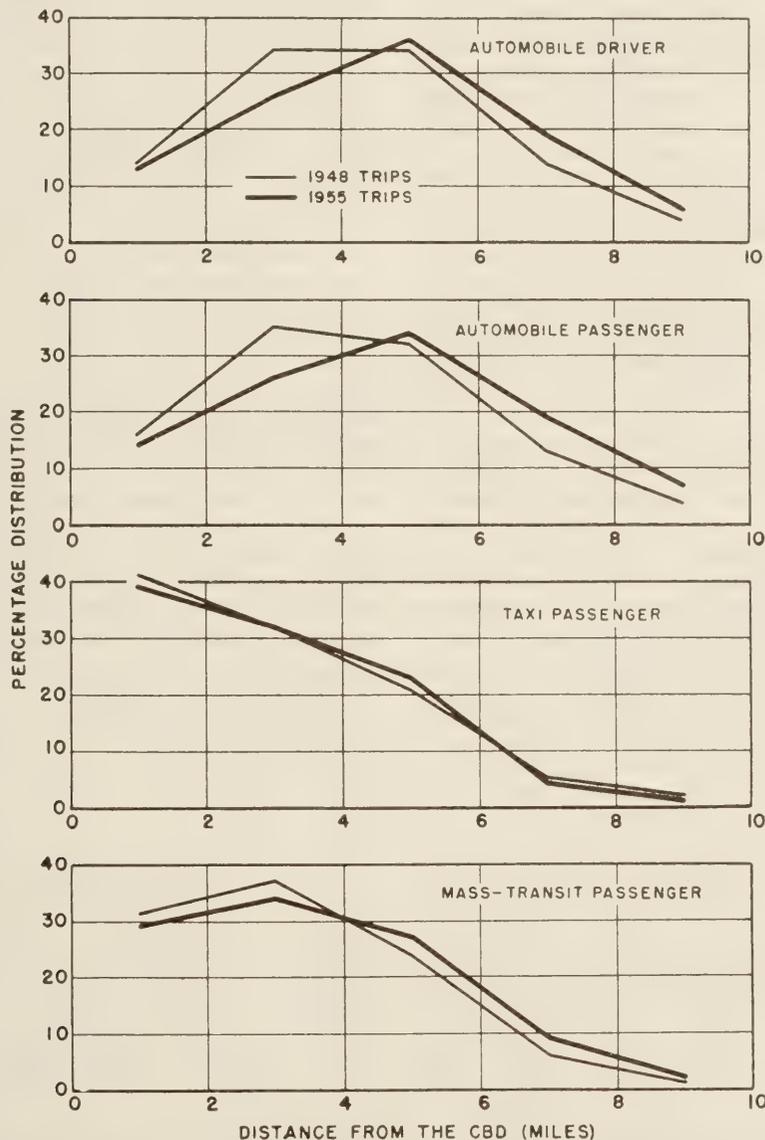
The percentage of total intra-area "other" trips that were made to the CBD decreased for residents of each ring (table 5). With the exception of trips made by residents 8 to 10 miles of the CBD, the percentage change indicated by the change ratio shown in table 5 increased with distance. In the case of the residents within the 8- to 10-mile ring, the proportion of intra-area trips made to the CBD was already very small.

Within each ring the change in the distribution pattern of travel modes to the CBD for "other" purposes varied somewhat from that which was indicated for work and shopping purposes. In neither of the latter two purposes did any of the separate modes of travel other than mass-transit passenger have a percentage of residents trips to the CBD greater than 50 percent in any of the distance rings. Automobile-driver trips to the CBD, however, were the dominant mode of travel by residents 8 to 10 miles of the CBD in 1948, and this same characteristic applied to residents beyond 4 miles of the CBD in 1955.

It was previously noted that for working and shopping trips there was a reduction during the 7-year period in the area in which half or more of the CBD trips were made by mass transit. In the case of "other" purposes, only residents within 2 miles of the CBD were in the 50 percent or more category

**Table 10.—Percentage distribution of trips to the central business district in 1948 and 1955, classified according to mode of travel and distance of residence from the CBD**

Distances from CBD	Automobile driver		Automobile passenger		Taxi passenger		Mass-transit passenger	
	1955	1948	1955	1948	1955	1948	1955	1948
0-2 miles.....	12.6	14.1	13.6	16.2	39.0	40.6	28.8	31.3
2-4 miles.....	25.5	34.2	26.6	35.0	32.2	31.9	34.2	37.2
4-6 miles.....	36.3	34.3	33.5	31.8	23.2	20.6	26.5	24.3
6-8 miles.....	19.2	13.7	19.3	13.4	4.4	5.4	8.6	6.3
8-10 miles.....	6.4	3.7	7.0	3.6	1.2	1.5	1.9	.9
Total area.....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0



**Figure 13.—Percentage distribution of automobile-driver, automobile-passenger, taxi-passenger, and mass-transit passenger trips to the CBD, according to distance from the CBD.**

**Table 11.—Number of trips per 100 dwelling units to the central business district in 1948 and 1955, classified according to mode of travel and distance of residence from the CBD**

Distances from CBD	Automobile driver		Automobile passenger		Taxi passenger		Mass-transit passenger	
	1955	1948	1955	1948	1955	1948	1955	1948
0-2 miles.....	9.9	8.9	6.5	6.3	4.8	5.3	32.7	53.5
2-4 miles.....	15.2	17.8	9.7	11.2	3.0	3.4	29.8	52.3
4-6 miles.....	22.2	22.5	12.5	12.8	2.2	2.8	23.6	43.1
6-8 miles.....	19.0	18.2	11.8	10.9	.7	1.5	12.5	22.5
8-10 miles.....	21.9	21.7	14.6	13.1	.6	1.8	9.3	13.7
Average, total area.....	17.0	16.8	10.4	10.3	2.7	3.4	24.7	45.4

in 1948. By 1955 the use of the private automobile had increased to the point that even residents at this distance made less than 50 percent of their total "other" purpose trips by mass transit.

**Modes of Travel**

In 1948 and 1955 the proportion of total residents trips to the CBD made by mass-transit passengers and taxi passengers decreased with distance from the CBD while those made by automobile drivers and automobile passengers increased (table 9). The major change which did take place between 1948 and 1955 was a shift in the mode of travel. In 1955 there was a smaller percentage of total residents trips to the CBD in each ring that were made by mass-transit passengers, whereas the proportion of CBD trips made by automobile drivers and automobile passengers increased.

In the subsequent discussion of taxi-passenger trips, it must be kept in mind that only residents taxi trips are included in this study. A very large proportion of taxi-passenger trips are made by nonresidents (transients and tourists).

**Automobile drivers**

The percentage distribution of trips to the CBD, classified according to mode of travel and distance, is shown in table 10 and figure 13. There was approximately the same percentage of automobile-driver trips to the CBD made by residents 2 to 4 and 4 to 6 miles from the CBD in 1948, 34.2 percent and 34.3 percent, respectively. This similarity

disappeared in 1955. Residents within 4 to 6 miles made by far the largest percentage of automobile-driver trips to the CBD, 36.3 percent.

Although residents of the 2- to 4-mile ring had a substantially smaller average number of automobile-driver trips to the CBD per 100 dwelling units in 1948 than that observed for residents of the 4- to 6-mile ring (table 11), the 2- to 4-mile ring included more dwelling units. This offsetting factor accounted for the similar percentage of the total automobile-driver trips destined to the CBD by residents of these two rings in 1948.

In contrast, the 4- to 6-mile ring in 1955 contained approximately as many dwelling units as the 2- to 4-mile ring. This characteristic, plus the fact that in 1955 residents 4 to 6 miles from the CBD continued to make approximately the same number of automobile-driver trips to the CBD per 100 dwelling units as they did in 1948, while the number of trips per 100 dwelling units in the 2- to 4-mile ring decreased. These factors caused the change in the distribution pattern in 1955.

The general tendency in 1948 and 1955 was for the average number of automobile-driver trips to the CBD per 100 dwelling units to increase for the first few rings and then remain at about the same level beyond 6 miles of the CBD. With an increase in residential development in the outer two rings, the percentage distribution curve for automobile drivers might tend to flatten beyond 4 miles and possibly extend over a greater distance than in 1948. This trend appeared to be taking place in 1955, as residents 6 to 8 and 8 to 10 miles from the CBD made one-fourth (25.6 percent) of the

total automobile-driver trips to the CBD. This compares with 17.4 percent in 1948.

The relationship between distance and the proportion of intra-area automobile-driver trips destined to the CBD remained the same during the period between 1948 and 1955; as distance from the CBD increased, the percentage of total intra-area automobile-driver trips destined to the CBD decreased (table 12). The percentage from each ring, however, was less in 1955 than in 1948.

The volume of automobile-driver trips to the CBD made by residents 6 to 8 miles from the CBD varied greatly for both years from those made by residents within 8 to 10 miles of the central area. Residents of both rings, however, made approximately the same percentage of their total intra-area automobile-driver trips to the CBD, 7.0 and 7.4 percent in 1948, and 5.1 and 5.0 percent in 1955.

With respect to the purposes for which residents made automobile-driver trips to the CBD, there was a general shift in the relative importance of work and "other" trips (table 8). The proportion of residents automobile-driver trips destined to the CBD for "other" purpose increased in each ring between 1948 and 1955 while the percentage for work decreased. By 1955, the percentage for "other" purposes had increased in the first two rings so that it was the principal purpose for residents within a 2-mile radius and ranked second for residents in the 2- to 4-mile ring. Work trips remained the dominant purpose for residents beyond 4 miles of the central area.

**Automobile passengers**

The distribution pattern of residents automobile-passenger trips to the CBD in 1948 and 1955 was similar to that of automobile-driver trips to the CBD (table 10 and figure 13). A comparison of the change ratio for automobile-driver and automobile-passenger trips (table 12), however, shows that the proportion of residents automobile-passenger trips to the CBD changed less between 1948 and 1955 than did the proportion of automobile-driver trips.

The major difference in the purpose distribution was that automobile-passenger work trips had become even more common in 1955

**Table 12.—Trips to the central business district in 1948 and 1955, classified according to mode of travel and distance of residence from the CBD**

Mode of travel comparisons	0 to 2 miles		2 to 4 miles		4 to 6 miles		6 to 8 miles		8 to 10 miles		Total area	
	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948
<b>Automobile driver trips:</b>												
Total intra-area trips.....	96,933	65,207	243,930	191,562	402,803	232,776	308,297	110,909	106,292	28,326	1,158,255	628,780
Trips to CBD.....	10,431	7,960	20,978	19,315	29,859	19,345	15,787	7,763	5,285	2,098	82,340	56,481
Percentage of trips to CBD.....	10.8	12.2	8.6	10.1	7.4	8.3	5.1	7.0	5.0	7.4	7.1	9.0
1955 percentage/1948 percentage.....	.89		.85		.89		.73		.68		.79	
1955 trips to CBD/1948 trips to CBD.....	1.31		1.09		1.54		2.03		2.52		1.46	
<b>Automobile passenger trips:</b>												
Total intra-area trips.....	57,770	41,676	132,184	110,496	195,841	127,611	152,354	62,056	52,866	14,304	591,015	356,143
Trips to CBD.....	6,846	5,612	13,407	12,137	16,890	11,055	9,763	4,648	3,537	1,264	50,443	34,716
Percentage of trips to CBD.....	11.9	13.5	10.1	11.0	8.6	8.7	6.4	7.5	6.7	8.8	8.5	9.7
1955 percentage/1948 percentage.....	.88		.92		.99		.85		.76		.88	
1955 trips to CBD/1948 trips to CBD.....	1.22		1.10		1.53		2.10		2.80		1.45	
<b>Taxi passenger trips:</b>												
Total intra-area trips.....	20,986	17,653	18,624	16,888	11,100	8,873	5,983	2,416	1,403	646	58,096	46,476
Trips to CBD.....	5,018	4,704	4,140	3,692	2,988	2,387	5,970	619	155	171	12,871	11,573
Percentage of trips to CBD.....	23.9	26.6	22.2	21.9	26.9	26.9	9.5	25.6	11.0	26.5	22.2	24.9
1955 percentage/1948 percentage.....	.90		1.01		1.00		.37		.42		.89	
1955 trips to CBD/1948 trips to CBD.....	1.07		1.12		1.25		.92		.91		1.11	
<b>Mass-transit passenger trips:</b>												
Total intra-area trips.....	168,109	215,110	200,877	245,270	164,548	164,312	70,122	47,036	18,026	6,470	621,682	678,198
Trips to CBD.....	34,507	47,798	41,043	56,794	31,812	37,095	10,385	9,556	2,258	1,325	120,005	152,568
Percentage of trips to CBD.....	20.5	22.2	20.4	23.2	19.3	22.6	14.8	20.3	12.5	20.5	19.3	22.5
1955 percentage/1948 percentage.....	.92		.88		.85		.73		.61		.86	
1955 trips to CBD/1948 trips to CBD.....	.72		.72		.86		1.09		1.70		.79	

**Table 13.—Percentage distribution of trips to the central business district in 1948 and 1955, classified according to purpose and sector of residence**

Sectors	Work trips		Shopping trips		Other trips		All purposes	
	1955	1948	1955	1948	1955	1948	1955	1948
0.....	0.3	0.6	0.5	0.3	4.2	5.8	1.4	2.0
1.....	6.5	5.4	5.6	6.6	7.4	7.6	6.6	6.1
2.....	16.7	15.2	14.3	16.9	15.9	16.3	16.2	15.7
3.....	27.1	32.2	30.0	30.7	24.5	25.0	26.7	30.0
4.....	12.4	11.8	13.5	13.7	12.0	10.0	12.4	11.6
5.....	7.1	8.3	9.4	7.8	7.6	7.3	7.5	8.0
6.....	12.0	9.8	16.0	12.1	12.0	10.3	12.5	10.2
7.....	8.9	9.5	6.1	7.5	8.9	11.8	8.6	9.9
8.....	9.0	7.2	4.6	4.4	7.5	5.9	8.1	6.5
Total area.....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

han they had been in 1948. Residents beyond 6 miles of the CBD made 63 percent or more of their total automobile-passenger trips to the CBD in 1955 for purposes of work. In the area beyond 6 miles, approximately 3 out of 4 residents traveling to the CBD as automobile passengers went there to work. In 1948 only residents of the 6- to 8-mile ring made over 50 percent of their automobile-passenger trips to the CBD for this purpose.

**Taxi passengers**

In comparison with other modes of travel, the percentage distribution of residents taxi-passenger trips made to the CBD changed only slightly between 1948 and 1955 (table 10 and figure 13). The largest percentage of reported taxi-passenger trips to the CBD were made by residents living closest to the CBD; those living within 4 miles made 72.5 percent of the total taxi trips to the CBD in 1948 and 71.2 percent in 1955.

The number of taxi-passenger trips to the CBD per 100 dwelling units was less in each distance ring in 1955 than it had been in 1948 (table 11), and in 1955 the number of trips per 100 dwelling units decreased with distance from the CBD. Because of this relationship, residential development beyond 4 miles of the CBD should have little effect on the percentage distribution of taxi-passenger trips to the CBD in the future.

Of significance was the change which occurred in the proportion of taxi-passenger trips made to the CBD by residents beyond 6 miles of the CBD (table 12). Although there were relatively few taxi-passenger trips made to the CBD by residents 6 to 8 and 8 to 10 miles from the central area, residents of both rings more than doubled the number of trips in the 7-year period. The percentage of total area trips going to the CBD, however, decreased. As indicated by the change ratio given in table 12, this decrease in percentage was in sharp contrast to the percentage change for the first three rings.

Apparently the purposes for which taxi-passenger trips were made were less influenced by distance from the CBD than they were by other characteristics peculiar to the residents of the ring (table 8). The erratic nature of the percentages for the 8- to 10-mile ring is probably due to the small sample of taxi-passenger trips.

One trend in the purpose distribution was apparent in that the percentage of residents taxi-passenger trips to work increased in all

but the 8- to 10-mile ring. By 1955, 50 percent or more of the taxi-passenger trips made to the CBD by residents within 8 miles of the CBD were for the purpose of work.

**Mass-transit passengers**

Of the four modes of travel studied, mass-transit passenger travel was the only mode that decreased in the overall volume of trips destined to the CBD. The residents accounting for this decrease lived within a 6-mile radius of the central area (table 12). Residents within this area still accounted for 92.8 percent of the mass-transit passenger trips destined to the CBD in 1948 and 89.5 percent in 1955 (table 10 and figure 13).

The decrease in the number of mass-transit passenger trips to the CBD per 100 dwelling units which occurred in each ring was equally significant (table 11). Since the number of trips per dwelling unit by automobile driver, automobile passenger, and taxi passenger changed only slightly, trips by mass transit accounted for the major proportion of the decrease within each ring. When residents changed their mode of travel to the CBD, it was usually a change from mass transit to one of the other modes.

In both years, as distance from the CBD increased, there was a progressive decrease in the number of mass-transit passenger trips per dwelling unit. This was in contrast to automobile-driver and automobile-passenger trips (table 11).

A change did occur in the relationship of distance and the percentage of residents intra-area mass-transit passenger trips destined to the CBD (table 12). In 1948, about the same proportion of CBD trips to total area trips was found for each 2-mile ring. By 1955, however, the proportion of residents mass-transit passenger trips destined to the CBD was progressively smaller with increased distance.

Work trips in both years accounted for the major proportion of mass-transit passenger trips to the CBD (table 8), and the proportion increased for each ring between 1948 and 1955. In contrast, the proportion of mass-transit shopping trips to the CBD decreased for each ring except for the area closest to the CBD.

**ANALYSIS OF DIRECTION FACTOR**

The sector subdivisions used in this study are much like a watershed of a stream. In general, along these sector divisions flow the major inbound and outbound CBD traffic.

As a result, the radial patterns of traffic provide still another means, besides distance, in analyzing the characteristics of travel to the CBD.

In the study of sectors, a different approach is taken from that used in the study of rings. The variation in distances from the CBD was the major criterion for interpreting much of the information in the ring analysis. In the study of sectors, the radial growth and distribution of population, socioeconomic characteristics, and historical trends come into play in influencing the patterns that develop and the changes which take place. It has been said that " \* \* \* the different types of residential areas tend to grow outward along rather distinct radii, and new growth on the arc of a given sector tends to take on the character of the initial growth in that sector \* \* \*."<sup>5</sup>

Although there was a shifting between sectors, there were no major changes in the overall pattern of residents CBD trip distribution by sectors as there had been by 2-mile rings (table 13). The percentage of trips to the CBD from 7 of the 9 sectors varied no more than  $\pm 1.6$  percentage points from what it had been in 1948, and even though the percentage of CBD trips made by residents of sector 3 decreased slightly due to the relative increases in the other sectors, the major peak in residents trip distribution remained in sector 3.

This pattern of distribution and the relative changes which took place between the two years are very similar to that which occurred for population and dwelling units, and it suggests a close relationship between the distribution of residents trips to the CBD and the distribution of residential development (fig. 14). It did not necessarily follow, however, that residents of a sector with a large number of trips to the CBD per dwelling unit also made a large percentage of all residents CBD trips (tables 13 and 14). It was not only the number of trips per dwelling unit that affected the pattern of distribution, but also the amount of residential development.

A change did appear to be taking place in the travel pattern of certain groups of contiguous sectors, which in 1948 had practically the same percentage of total trips destined to the CBD (table 15). In 1948 the percentage of CBD trips made by residents of sectors 1, 2, and 3 ranged from 16.0 to 16.4 percent; that by residents of sectors 4, 5, and 6 ranged from 13.5 to 14.3 percent; and that by residents of sectors 7 and 8 ranged from 12.3 to 12.5 percent. By 1955, all the percentages had decreased, and the decrease was such that the range between percentages for these sector groups was somewhat larger than in 1948.

It is difficult to say whether these differences between the 1948 and 1955 pattern were due to a trend that was taking place or to chance. If, however, these differences persist or increase, they may indicate a breaking up of the groups and the beginning of new sector groupings with a similar orientation of intra-area trips destined to the CBD.

<sup>5</sup> *The Structure and Growth of Residential Neighborhoods in American Cities*. Federal Housing Administration, Washington, D.C., 1939, p. 114.

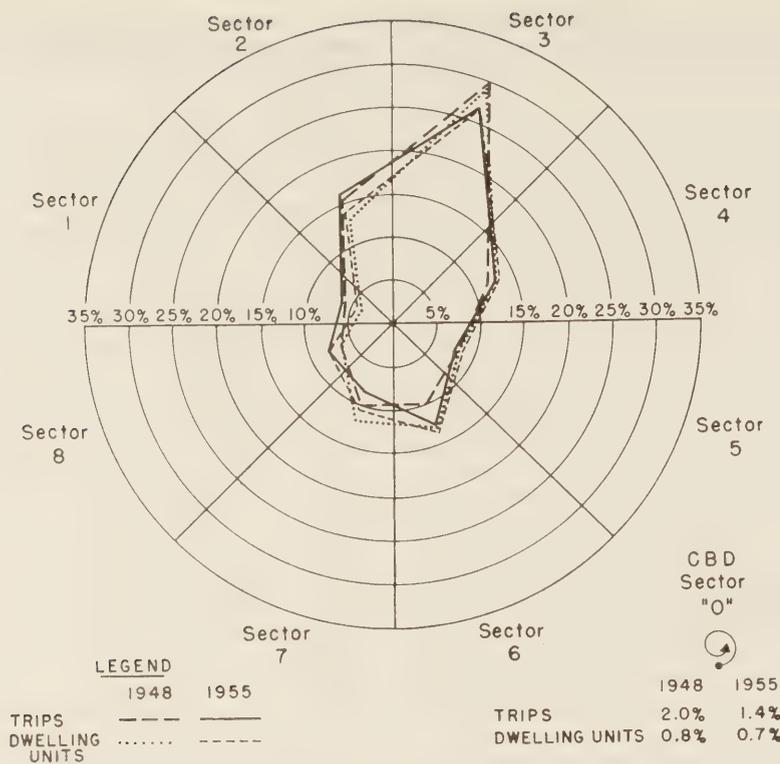


Figure 14.—Percentage distribution of residents CBD trips and dwelling units, according to sector of residence.

### Trip Purposes

The change in the percentage distribution of CBD trip purposes varied from sector to sector (table 16). The overall trend, however, was one of decreasing differences between sectors in the proportion of residents trips for work and "other" purposes. Excluding trips made by residents of sector zero, the range between the highest and the lowest percentage of CBD work trips decreased from 14.4 percent in 1948 to 10.6 percent in 1955. More striking was the decrease in the range for "other" trips, 11.1 to 5.4 percent.

Shopping trips, on the other hand, increased slightly in the percentage range among sectors. The spread among the percentages in 1948 was 6.9 percent, and in 1955 it was 8.4 percent. This characteristic of shopping trips can be attributed to the unbalanced development of commercial facilities among the sectors. An example of this is indicated by the distribution of trip purposes for residents of sectors 5 and 6. The area included by these sectors had a relatively sparse development of major commercial activity in relation to residential growth prior to the 1948 study, and comparatively few shopping concentrations had been added by 1955. The result, as indicated in table 16, was that residents of these sectors maintained a higher percentage of their trips to the CBD for purposes of shopping than did the residents of the other sectors.

### Work trips

The 1955 distribution pattern among the sectors of residents work trips to the CBD varied no more than  $\pm 2.2$  percentage points in all sectors, except sector 3, from the corresponding percentage in 1948 (table 13 and figure 15). Although the percentage made by

residents of sector 3 decreased, the large number of residents of this sector still accounted for the major peak in the pattern of work trip distribution (32.2 percent in 1948 and 27.1 percent in 1955).

Figure 16 shows the relationship between the number of CBD work trips per 100 dwelling units of a sector in 1948 and 1955 and the number of employment opportunities per 100 dwelling units in that sector. With some exceptions, the general trend in each of the years was for the number of CBD work trips per 100 dwelling units to decrease as the number of employment opportunities per 100 dwelling units in a given sector increased. Employees tend to work at locations closer to their place of residence if there is an opportunity to do so, or conversely, they tend to live in the vicinity of their work.

In comparing the positions of the plotted symbols in figure 16 for the two years, it is seen that for a given sector the plotted symbols for 1955 fall to the left of those for 1948, except in the case of sector 7. The reason for this relation is that the rate of residential develop-

ment in each of the sectors except sector 7 exceeded the rate of growth in employment opportunities in the corresponding sector.

The percentage of residents intra-area work trips destined to the CBD decreased in all sectors with the exception of sector 1 (table 13). The amount of decrease varied with each sector, resulting in a new geographic relationship between sectors 1 through 5. Beginning with sector 1 and following around the central area through sector 5, it is apparent that there was a continual decrease between sectors in the proportion of 1955 intra-area work trips destined to the CBD. Although there are a few exceptions, this transition appears to be one from sectors with high average family income and with a large proportion of professional and white-collar employees to one of lower average family incomes and a large proportion of blue-collar employees. Thus, there is an indirect inference that an increasing number of employment opportunities were afforded blue-collar employees outside the CBD in 1955.

The increase in automobile ownership caused a decline in the proportion of mass transit work trips made by sector residents (tables 17 and 18). For example, in both 1948 and 1955 the average number of automobiles owned per 100 dwelling units by residents of sectors 0, 3, 5, and 6 was below the study area average. On the other hand, the percentage of work trips by mass transit for residents of each of these sectors was well above the average. As the number of automobiles owned per dwelling unit increased between 1948 and 1955 in all sectors, except sector zero, there was a decrease, with the exception of sectors 0 and 1, in the proportion of work trips by mass transit and a corresponding increase in those by automobile.

### Shopping trips

The distribution pattern of sector resident shopping trips to the CBD in 1955 did not change materially from that in 1948 (table 13 and figure 15); six of the sectors had a change within  $\pm 1.5$  percentage points. The largest relative change, an approximate 4-percent increase, took place in sector 6, and was caused by a population increase of approximately 53,000 persons, the second largest increase in the study area. The residents of sector 6 were not served as adequately by major suburban shopping facilities as were other sectors. With few new commercial developments in this sector between 1948 and 1955, and with the large increase in population, there was an increase in the number of CBD trips.

Table 14.—Number of trips per 100 dwelling units to the central business district in 1948 and 1955, classified according to purpose and sector of residence

Sectors	Work trips		Shopping trips		Other trips		All purposes	
	1955	1948	1955	1948	1955	1948	1955	1948
0.....	15.4	32.9	4.9	4.0	91.9	148.0	112.2	184.9
1.....	47.5	61.1	7.8	17.3	24.1	40.3	79.4	118.8
2.....	40.2	51.3	6.7	13.0	17.1	25.6	64.1	89.9
3.....	34.2	49.4	7.3	10.7	13.8	17.8	55.3	77.9
4.....	31.5	41.6	6.6	11.0	13.6	16.3	51.8	68.9
5.....	27.3	45.3	7.0	9.6	13.1	18.3	47.4	73.3
6.....	29.3	33.4	7.5	9.4	13.1	16.3	49.9	59.1
7.....	27.7	35.8	3.7	6.5	12.4	20.7	43.8	62.9
8.....	36.7	48.9	3.6	6.7	13.6	18.6	53.9	74.3
Average, total area.....	33.4	44.9	6.4	10.2	14.9	20.8	54.8	76.0

Table 15.—Trips to the central business district in 1948 and 1955, classified according to purpose and sector of residence

Trip purpose comparisons	Sector 0		Sector 1		Sector 2		Sector 3		Sector 4		Sector 5		Sector 6		Sector 7		Sector 8		Total area		
	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955
	Work trips:	1,662	2,127	27,354	21,940	73,913	54,815	150,000	135,349	85,549	66,587	40,752	72,810	51,684	58,006	45,624	54,358	33,316	575,383	452,194	1,662
Trips to CBD	511	911	10,581	8,071	27,075	22,952	43,895	48,609	20,067	17,842	12,560	19,520	14,744	14,393	14,310	14,624	10,867	162,092	150,866	511	911
Percentage of trips to the CBD	30.7	42.8	38.7	36.8	36.6	41.9	29.2	35.9	23.5	26.8	30.8	26.8	28.5	24.8	31.4	26.9	32.6	26.2	33.4	30.7	42.8
1955 percentage/1948 percentage	.72	1.05	1.05	.87	.87	.87	.81	.88	.88	.88	.88	.88	.88	.79	.83	.83	.83	.84	.84	.72	1.05
1955 trips to CBD/1948 trips to CBD	.56	1.31	1.31	1.18	1.18	1.18	.90	.90	1.12	1.12	1.12	1.32	1.32	1.01	1.01	1.01	1.01	.84	.84	.56	1.31
Shopping trips:	544	156	12,242	7,287	31,426	20,334	36,848	24,597	23,936	13,302	7,631	19,675	10,242	25,213	17,025	29,481	9,586	192,217	110,160	544	156
Trips to CBD	163	112	1,745	2,289	4,476	5,816	10,570	4,223	4,223	4,723	2,665	4,995	4,152	1,913	2,587	1,410	1,497	31,235	34,411	163	112
Percentage of trips to the CBD	30.0	71.8	14.3	31.4	14.2	28.6	25.4	43.0	17.6	35.5	34.9	25.4	40.5	7.6	15.2	4.8	15.6	16.2	31.2	30.0	71.8
1955 percentage/1948 percentage	.42	.46	.46	.50	.50	.50	.59	.59	.50	.50	.50	.63	.63	.50	.31	.31	.31	.52	.52	.42	.46
1955 trips to CBD/1948 trips to CBD	1.46	.76	.76	.77	.77	.77	.88	.88	.89	.89	.89	1.20	1.20	.74	.74	.74	.95	.91	.91	1.46	.76
Other trips:	4,172	5,490	93,861	66,189	255,963	176,614	377,695	314,107	238,828	139,503	93,144	197,096	122,839	178,191	138,605	184,026	90,752	1,661,448	1,147,243	4,172	5,490
Trips to CBD	3,054	4,094	5,365	5,321	11,551	11,427	17,524	17,524	8,683	7,009	5,083	8,704	7,187	6,439	8,287	5,412	4,129	72,332	70,061	3,054	4,094
Percentage of trips to the CBD	73.2	74.6	5.7	8.0	4.5	6.5	4.7	5.6	3.6	5.0	5.5	4.4	5.9	3.6	6.0	2.9	4.5	44.1	6.1	73.2	74.6
1955 percentage/1948 percentage	.98	.71	.71	.69	.69	.69	.84	.84	.72	.72	.72	.75	.75	.75	.75	.75	.64	.72	.72	.98	.71
1955 trips to CBD/1948 trips to CBD	.75	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.24	1.24	1.24	1.21	1.21	.78	.78	1.31	1.03	1.03	.75	1.01	
All purposes:	6,378	7,773	133,457	95,416	361,302	251,763	564,633	474,053	348,313	219,392	141,597	289,581	184,765	261,410	201,254	267,865	133,654	2,429,048	1,709,597	6,378	7,773
Trips to CBD	3,728	5,117	17,691	15,681	43,082	40,195	70,940	76,703	32,973	29,574	20,308	33,219	26,083	22,735	25,184	21,455	16,493	265,059	255,388	3,728	5,117
Percentage of trips to the CBD	58.5	65.8	13.3	16.4	11.9	16.0	12.6	16.2	9.5	13.5	14.3	11.5	14.1	8.7	12.5	8.0	12.3	10.9	14.9	58.5	65.8
1955 percentage/1948 percentage	.89	.81	.81	.74	.74	.74	.78	.78	.70	.70	.70	.82	.82	.70	.70	.65	.73	.73	.73	.89	.81
1955 trips to CBD/1948 trips to CBD	.73	1.13	1.13	1.07	1.07	1.07	.92	.92	1.11	1.11	1.11	1.27	1.27	.90	.90	1.30	1.04	1.04	.73	.73	

Table 16.—Percentage distribution of trips to the central business district in 1948 and 1955, classified according to mode of travel and sector of residence

Trip purpose of mode of travel	Sector 0		Sector 1		Sector 2		Sector 3		Sector 4		Sector 5		Sector 6		Sector 7		Sector 8		Total area		
	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955
	Automobile-driver trips to—	14.2	17.2	54.5	49.1	55.3	58.6	50.5	62.5	52.4	60.1	44.6	54.3	44.4	56.7	53.1	46.7	56.0	59.2	55.9	14.2
Work	1.11	8.7	1.11	8.0	1.00	6.2	.81	6.1	.87	7.0	12.1	7.5	7.8	7.5	1.14	8.7	.95	5.1	.92	1.11	8.7
Ratio, 1955/1948	5.9	7.4	5.9	8.0	5.9	6.2	6.2	6.1	8.3	7.0	12.1	7.5	10.1	7.5	7.5	8.7	4.2	5.1	7.2	5.9	7.4
Shop.	100.0	85.8	39.6	42.9	38.8	38.5	43.3	31.4	39.3	32.9	43.3	38.2	45.5	35.8	39.4	44.6	39.8	35.7	41.6	100.0	85.8
Other	1.17	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	1.17	100.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Automobile-passenger trips to—	17.2	18.1	44.7	51.6	63.3	58.6	71.3	57.2	72.8	52.0	72.7	57.1	63.0	51.4	62.9	51.4	73.2	66.2	55.1	17.2	18.1
Work	8.8	9.2	9.2	11.4	10.8	10.5	9.9	10.3	14.0	14.6	10.4	13.7	14.2	11.1	7.6	8.2	11.1	6.0	8.9	8.8	9.2
Ratio, 1955/1948	91.2	82.8	46.1	37.0	26.2	31.5	20.6	32.5	20.4	33.4	16.9	29.2	22.8	37.5	29.5	40.4	21.7	27.8	24.9	91.2	82.8
Other	1.10	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	1.10	100.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Taxi-passenger trips to—	21.3	18.1	60.2	41.5	60.8	48.8	58.3	59.8	36.6	57.1	64.2	38.3	57.9	17.0	22.0	41.7	56.3	60.0	54.7	21.3	18.1
Work	1.18	7.4	1.45	15.2	4.7	12.6	15.6	8.4	16.9	28.6	17.9	26.0	19.6	10.3	24.6	41.7	12.5	9.4	12.3	1.18	7.4
Ratio, 1955/1948	71.3	81.9	30.2	43.3	34.5	38.6	26.1	31.8	46.5	14.3	17.9	35.7	22.5	72.7	53.4	58.3	31.2	40.0	33.0	71.3	81.9
Other	1.87	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	1.87	100.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mass-transit passenger trips to—	17.7	18.5	69.9	54.5	68.9	58.8	64.7	64.6	63.0	62.7	60.4	66.3	66.3	59.0	77.6	65.4	81.6	72.1	66.2	17.7	18.5
Work	3.4	3.2	13.0	20.3	15.0	19.6	17.7	16.4	19.0	19.4	17.8	13.7	18.2	20.1	9.0	12.6	10.8	14.8	16.0	3.4	3.2
Ratio, 1955/1948	106	78.3	17.1	25.2	16.1	21.6	17.6	19.0	18.0	17.9	21.8	20.0	15.5	20.9	13.4	22.0	7.6	13.1	17.8	106	78.3
Other	1.01	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	1.01	100.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
All modes of travel to—	13.7	17.8	59.8	51.5	62.8	57.1	61.9	63.4	60.9	60.3	57.6	61.9	58.8	56.5	63.3	56.8	68.2	65.9	61.0	13.7	17.8
Work	4.4	2.2	9.9	14.6	10.4	14.5	13.2	13.8	12.8	16.0	14.9	13.1	15.0	15.9	8.4	10.3	6.6	9.1	11.8	4.4	2.2
Ratio, 1955/1948	2.00	80.0	30.3	33.9	26.8	28.4	24.9	22.8	26.3	23.7	27.5	25.0	26.2	27.6	28.3	32.9	25.2	25.0	27.2	2.00	80.0
Other	1.02	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	1.02	100.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

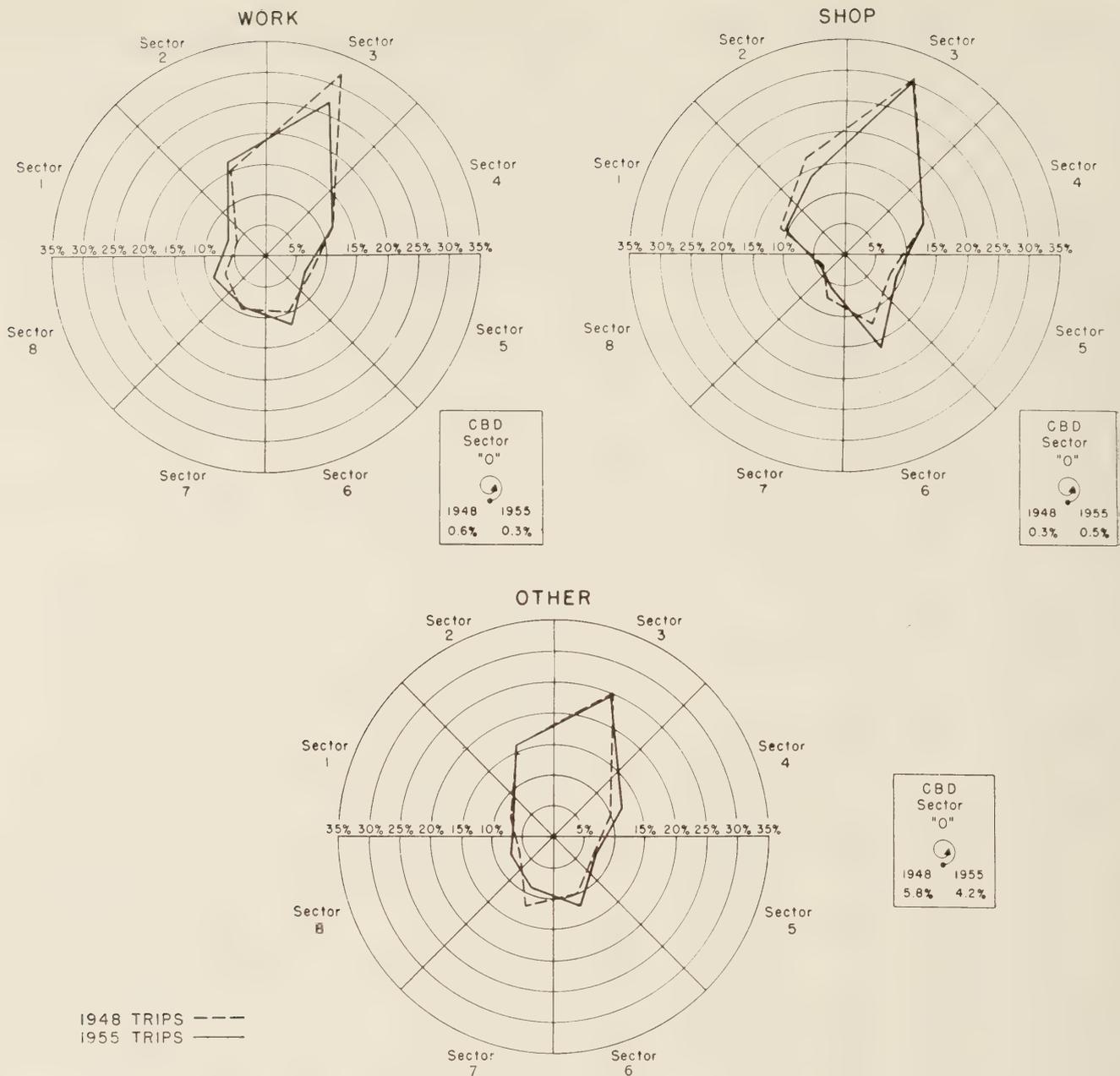


Figure 15.—Percentage distribution of work, shop, and other purpose trips to the CBD, according to sector of residence.

The number of commercial concentrations increased in the various sectors, and thus contributed in part to the decrease in the number of shopping trips per dwelling unit. The increasing uniformity of CBD shopping trips by sector residents illustrates, however, that the central area continued to offer certain shopping advantages that were not satisfied elsewhere (table 14). If residents trips of sectors 0, 7, and 8 are excluded, the range between the sector with the greatest number of shopping trips per dwelling unit and the sector with the least number was only 1.2 trips. In 1948 the range was 7.9 trips.

Although the actual volume of intra-area shopping trips increased between 1948 and 1955, it is apparent from the change ratio (table 15) that the orientation of these trips by residents of each sector had changed significantly. The percentage of intra-area shopping trips to the CBD in 1955 decreased by one-third for residents in all sectors, and

for residents in six of the sectors the percentage decreased by one-half or more.

Shopping trips for the two years by residents of sector 8 illustrate an extreme of this decreasing percentage of intra-area trips to the CBD. This sector is relatively more suburban in character than many of the other sectors at similar distances from the CBD. In 1948, 1,497 or 15.6 percent of 9,586 shopping trips by residents of sector 8 were destined to the CBD. In 1955 intra-area shopping trips had increased to 29,481, but the volume to the CBD remained approximately the same as in 1948 (1,419 trips), a drop from 15.6 to 4.8 percent.

There are certain geographic factors which had a great effect on trips to the CBD by residents of Virginia, especially shopping trips. It would be well, therefore, to discuss more fully sectors 7 and 8 which make up the Virginia portion of the study area. Although 2 of the 4 bridges across the Potomac River lead directly to the CBD, there was a low

orientation in the 1948 study of shopping trips to the CBD by residents of sectors 7 and 8 compared with similar trips made by residents of the other sectors (table 15). The relatively low percentages of shopping trips to the CBD became more pronounced in 1955 as increased suburban commercial development took place.

This recent history of shopping trips by residents of sectors 7 and 8 illustrates a lesser dependency on the Washington CBD for shopping purposes than was the case for other sectors. The Potomac River, because of its restricting effect on direct travel, is a psychological as well as a physical barrier to travel by Virginians to the Washington CBD. As a result, several large commercial concentrations, such as that found in the Clarendon section of Arlington, had developed before the 1948 study, and they were serving many of the retail needs of Virginia residents. Since that time, these centers have been greatly augmented by other regional as well as neighborhood

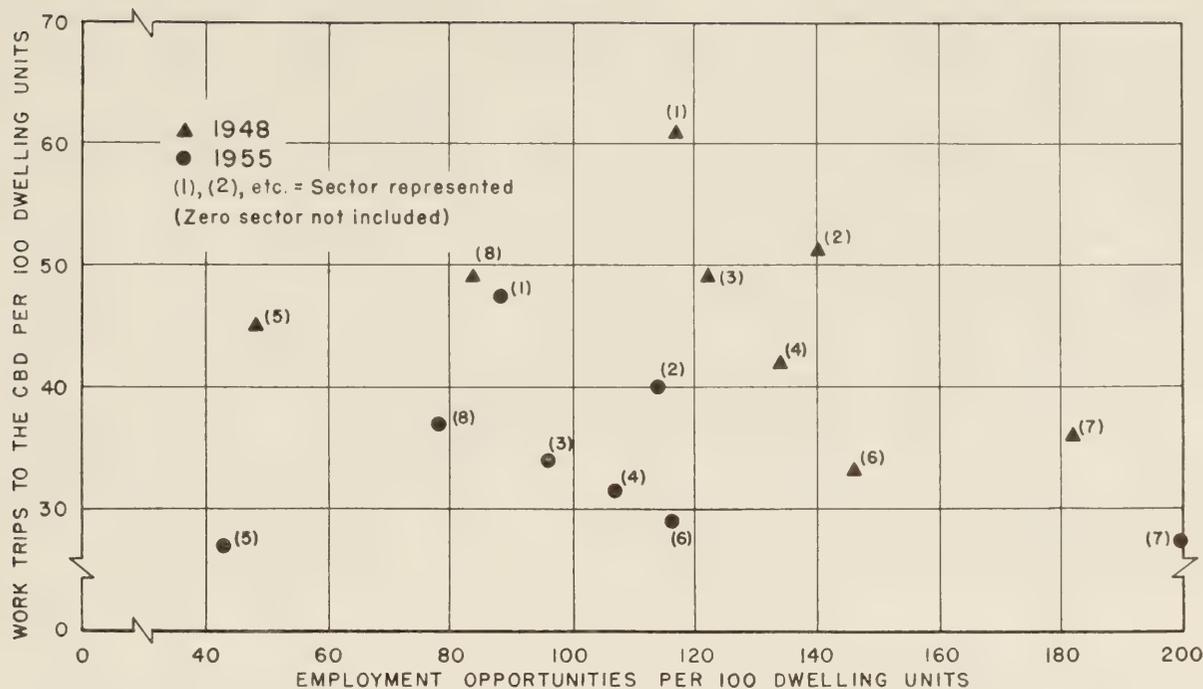


Figure 16.—Relation of the number of CBD work trips per 100 dwelling units to the number of employment opportunities per 100 dwelling units, according to sector of residence.

type retail concentrations. Thus, there appeared to be an even lower orientation of shopping trips to the CBD in 1955.

The close tie that is usually considered to exist between shopping trips to the CBD and mass transit is largely substantiated by the data for 1948 (table 18). In 1948, residents of each of the 9 sectors made 60 percent or more of their CBD shopping trips by mass transit. This relation had changed by 1955 when only sectors 3, 4, and 5 maintained as high a percentage. Even in these three sectors, the percentage was less in 1955 than it had been in 1948.

The variation between sectors in the percentage change in mode of travel might best be explained by comparing the CBD shopping trips made by residents of sectors 3 and 7. Sector 3 had convenient mass-transit service, and there was a below area average increase in automobiles owned per 100 dwelling units (24.0 percent). Between 1948 and 1955, the percentage of CBD shopping trips by mass transit decreased from 82.9 to 72.0 percent in sector 3. Even with this decrease, the percentage remained high. In contrast, trips made by residents of sector 7 changed radically. Sector 7 had a relatively less convenient mass-transit system than sector 3, but there was a very large increase in the number of automobiles per 100 dwelling units (54.0 percent). In 1948 mass transit carried nearly two-thirds (62.1 percent) of all the residents of sector 7 destined to the CBD for shopping. By 1955 the proportion was slightly more than one-third (37.5 percent).

#### Other purpose trips

As mentioned previously in the study of distance rings, it is possible only to make generalizations of the changes that took place in the "other" trip purpose category. This group, however, did show a similarity in

several characteristics that were found for work and shopping trips.

The pattern of "other" trip purpose distribution changed only slightly between 1948 and 1955. Trips by residents of 4 of the 9 sectors in 1955 were within  $\pm 0.5$  percent of the 1948 percentage, and 3 other sectors were within  $\pm 1.7$  percentage points (table 13 and figure 15). As in work and shopping trips, the peak trip distribution was in sector 3 which had the largest number of residents.

The number of "other" purpose trips to the CBD per 100 dwelling units decreased for residents of all sectors (table 14), and the trend was toward greater uniformity in the distribution of trips per dwelling unit between each of the sectors, particularly sectors 3 through 8.

The distribution of the modes of travel by which "other" purpose trips were made indicates a large increase in the percentage of trips by automobile drivers for each sector between 1948 and 1955 (table 18). Here again, this change in mode of travel was apparently due to an increase in the automobile ownership ratio. In 1948 residents of only two sectors, 1 and 8, made 40 percent or more of their CBD "other" purpose trips as automobile drivers. At that time, these two sectors contained the largest number of automobiles per dwelling unit. With an increase in the number of automobiles owned, residents of each sector in 1955, except sector zero, made 40 percent or more of their "other" purpose trips as automobile drivers.

#### Modes of Travel

In 1948 and 1955, there was an inverse relationship between automobile ownership and the percentage of residents CBD trips made by mass-transit passengers. If the sectors are listed in accordance with automobiles owned per 100 dwelling units from

the highest to the lowest and then by the percentage of residents CBD trips made by mass-transit passengers (table 18) from the lowest to the highest, it will be seen that for both years the sequence of the sectors was nearly the same. Exceptions to this sequence were sectors 4 and 7 in 1948 and 1, 2, and 7 in 1955.

Since there was a general tendency for smaller percentages of mass-transit passenger trips to be made by residents of sectors with a greater number of automobiles owned per dwelling unit, it followed that with increased automobile ownership within each sector, with the exception of sector zero, the percentage of CBD trips by mass transit decreased. The changes which occurred within each sector in the percentage distribution of mode of travel to the CBD resulted in an increasing similarity of these percentages between sectors (table 18).

To illustrate this increasing uniformity, residents of sectors 1 through 6 (District of

Table 17.—Average annual family income for 1955 and average number of automobiles owned per 100 dwelling units, grouped by sector of residence

Sectors	Average income, 1955 <sup>1</sup>	Number of automobiles owned per 100 dwelling units		
		1955	1948	Ratio, 1955/1948
0.....	\$4,300	19	23	0.83
1.....	10,100	96	86	1.12
2.....	9,900	82	70	1.17
3.....	5,600	62	50	1.24
4.....	5,900	88	71	1.24
5.....	4,800	70	52	1.35
6.....	5,400	73	53	1.38
7.....	7,200	91	59	1.54
8.....	8,300	109	91	1.20
Average, total area.....	6,700	79	61	1.30

<sup>1</sup> Figures for 1948 are not shown because the data for the 2 years are not comparable.

Table 18.—Percentage distribution of trips to the central business district in 1948 and 1955, classified according to mode of travel of trip purpose and by sector of residence

Mode of travel of trip purpose	Sector 0		Sector 1		Sector 2		Sector 3		Sector 4		Sector 5		Sector 6		Sector 7		Sector 8		Total area		
	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	
Work trips by—																					
Automobile drivers—																					
Ratio, 1955/1948	9.8	28.2	30.2	22.8	20.4	15.6	28.5	22.9	23.8	16.0	23.0	22.2	33.2	23.1	33.7	32.4	26.0	20.9			
Automobile passengers—																					
Ratio, 1955/1948	12.5	18.9	17.3	14.9	18.5	8.9	25.6	13.4	20.0	10.4	19.5	11.7	1.44	16.0	28.9	19.9	20.6	12.7			
Taxi passengers—																					
Ratio, 1955/1948	5.2	8.2	4.8	7.0	5.0	4.4	1.7	1.9	2.3	2.7	3.4	.7	.7	2.7	.73	3.0	1.19	3.7			
Mass-transit passengers—																					
Ratio, 1955/1948	75.9	50.1	47.7	55.3	56.1	71.1	44.2	61.8	53.9	70.9	54.1	65.4	48.0	58.2	35.2	44.7	49.0	62.7			
Total—	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
Shopping trips by—																					
Automobile drivers—																					
Ratio, 1955/1948	18.6	1.06	17.5	10.1	11.9	7.0	21.4	10.1	24.9	10.3	20.4	10.4	35.2	23.7	26.3	20.3	19.0	11.1			
Automobile passengers—																					
Ratio, 1955/1948	28.2	16.9	13.5	9.9	9.8	7.3	11.3	14.3	11.1	11.8	17.2	9.0	1.49	14.2	20.7	13.0	1.71	10.4			
Taxi passengers—																					
Ratio, 1955/1948	26.4	7.9	6.2	7.2	6.3	2.8	3.7	3.5	2.4	8.7	4.5	1.5	1.49	6.2	1.99	1.38	1.38	10.4			
Mass-transit passengers—																					
Ratio, 1955/1948	45.4	56.6	62.8	72.8	72.0	82.9	63.6	72.1	61.6	69.2	57.9	79.1	37.5	62.1	47.9	66.7	66.6	74.6			
Total—	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
Other trips by—																					
Automobile drivers—																					
Ratio, 1955/1948	14.5	1.0	40.0	31.8	43.5	21.8	49.4	31.9	48.3	27.8	53.0	28.7	55.1	38.1	64.6	51.4	47.3	30.1			
Automobile passengers—																					
Ratio, 1955/1948	15.5	27.3	18.8	16.1	13.2	14.0	16.6	21.9	9.7	13.2	15.8	17.5	1.12	21.7	23.2	22.0	1.73	17.1			
Taxi passengers—																					
Ratio, 1955/1948	13.5	8.1	7.6	11.2	5.5	6.4	4.9	1.2	1.3	6.2	2.9	6.1	.63	6.4	3.3	5.2	.59	6.6			
Mass-transit passengers—																					
Ratio, 1955/1948	2.60	1.07	33.6	40.9	37.7	57.8	29.1	45.0	40.7	52.8	28.3	47.7	16.7	33.8	8.9	21.4	29.3	46.2			
Total—	83	72	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		
All purposes by—																					
Automobile drivers—																					
Ratio, 1955/1948	11.9	12.3	31.7	23.5	25.1	15.8	33.1	23.0	30.7	18.2	30.5	22.1	39.6	28.1	41.0	36.1	31.0	22.1			
Automobile passengers—																					
Ratio, 1955/1948	13.9	12.9	17.2	14.5	16.0	9.8	21.4	15.5	15.9	11.3	18.2	12.9	23.2	17.7	26.9	19.8	19.0	13.6			
Taxi passengers—																					
Ratio, 1955/1948	15.5	5.1	6.0	8.3	5.3	4.7	2.8	2.0	2.0	4.4	3.4	2.3	2.1	3.6	2.7	3.2	1.8	4.5			
Mass-transit passengers—																					
Ratio, 1955/1948	58.7	69.7	45.1	53.7	53.6	69.7	42.7	59.5	51.4	66.1	47.9	62.7	35.1	50.6	29.4	40.9	45.2	59.8			
Total—	84	95	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0		

Table 19.—Trips to the central business district in 1948 and 1955, classified according to mode of travel and sector of residence

Mode of travel comparisons	Sector 0		Sector 1		Sector 2		Sector 3		Sector 4		Sector 5		Sector 6		Sector 7		Sector 8		Total area		
	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	1955	1948	
Automobile driver trips:																					
Total intra-area trips	1,141	1,032	65,152	40,488	186,146	105,257	226,023	136,638	172,247	83,868	39,873	131,493	64,564	149,594	89,014	140,594	68,046	1,158,255	628,780		
Trips to CBD	442	628	5,483	4,965	13,725	9,459	17,776	12,138	10,919	6,797	3,704	10,124	5,769	8,788	7,072	8,788	5,949	82,340	56,481		
Percentage of trips to the CBD	38.7	60.9	8.4	12.3	7.4	9.0	8.9	8.9	6.3	8.1	7.4	8.9	8.9	7.9	7.9	7.9	5.1	7.1	9.0		
1955 percentage/1948 percentage	.64	.68	.82	.88	.82	.88	.89	.99	.78	.75	.80	.88	.88	.88	.88	.88	.79	.79	.79		
1955 trips to CBD/1948 trips to CBD	.70	.70	1.10	1.38	1.45	1.45	1.46	1.61	1.61	1.61	1.64	1.75	1.75	1.27	1.27	1.48	1.48	1.46			
Automobile passenger trips:																					
Total intra-area trips	905	1,055	33,062	22,552	92,274	58,784	122,682	80,125	88,098	43,457	22,750	68,490	37,844	74,798	52,440	74,798	37,136	591,015	356,143		
Trips to CBD	524	259	4,785	3,535	13,571	10,251	20,688	15,337	4,964	3,354	4,649	5,202	4,890	1,746	3,035	1,746	1,166	58,096	46,476		
Percentage of trips to the CBD	57.5	24.6	14.5	14.5	14.5	17.3	19.0	19.0	5.6	7.7	21.3	12.3	12.9	2.3	5.8	2.3	3.1	12.8	13.1		
1955 percentage/1948 percentage	.92	.80	.80	.88	.88	.88	.99	.99	.75	.75	.78	.88	.88	.88	.88	.88	.88	.88	.88		
1955 trips to CBD/1948 trips to CBD	.79	.79	1.18	1.38	1.38	1.38	1.51	1.51	1.53	1.53	1.37	1.80	1.90	1.19	1.19	1.77	1.77	1.45			
Taxi passenger trips:																					
Total intra-area trips	824	259	30,458	28,841	69,311	77,471	195,240	241,953	82,404	88,713	74,255	84,396	77,407	45,514	56,765	41,727	27,306	621,682	678,198		
Trips to CBD	188	3,568	7,585	7,073	17,721	21,590	38,016	53,463	14,088	17,596	10,198	15,926	16,362	12,746	12,746	6,308	6,744	120,005	152,568		
Percentage of trips to the CBD	22.8	13.8	25.0	24.5	25.6	27.9	22.1	22.1	17.5	19.8	14.8	18.1	21.1	17.5	22.5	15.1	24.7	19.3	22.5		
1955 percentage/1948 percentage	.62	.63	1.02	1.02	.92	.92	.88	.88	.86	.86	.82	.82	.90	.78	.78	.61	.61	.86	.86		
1955 trips to CBD/1948 trips to CBD	.61	.61	1.07	1.07	.82	.82	.71	.71	.80	.80	.76	.97	.97	.63	.63	.94	.94	.79	.79		

**Table 20.—Percentage distribution of trips to the central business district in 1948 and 1955, classified according to mode of travel and sector of residence**

Sectors	Automobile driver		Automobile passenger		Taxi passenger		Mass-transit passenger	
	1955	1948	1955	1948	1955	1948	1955	1948
0.....	0.5	1.1	1.0	1.9	4.5	2.2	1.8	2.3
1.....	6.6	8.8	6.3	7.8	11.2	8.1	6.3	4.6
2.....	16.7	16.8	16.0	16.8	27.7	28.6	14.8	14.2
3.....	21.6	21.5	22.6	21.7	29.3	30.7	31.7	35.1
4.....	13.3	12.0	14.0	13.3	7.1	5.0	11.7	11.5
5.....	7.4	6.6	6.2	6.6	3.1	7.7	8.5	8.8
6.....	12.3	10.2	12.0	9.7	8.8	5.2	13.3	10.7
7.....	10.9	12.5	10.5	12.8	3.8	7.9	6.6	8.4
8.....	10.7	10.5	11.4	9.4	4.5	4.6	5.3	4.4
Total area.....	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Columbia and Maryland) were considered as one group, and residents of sectors 7 and 8 (Virginia) were considered as a second group. Residents of sector zero were excluded in the analysis. In the first group, the range

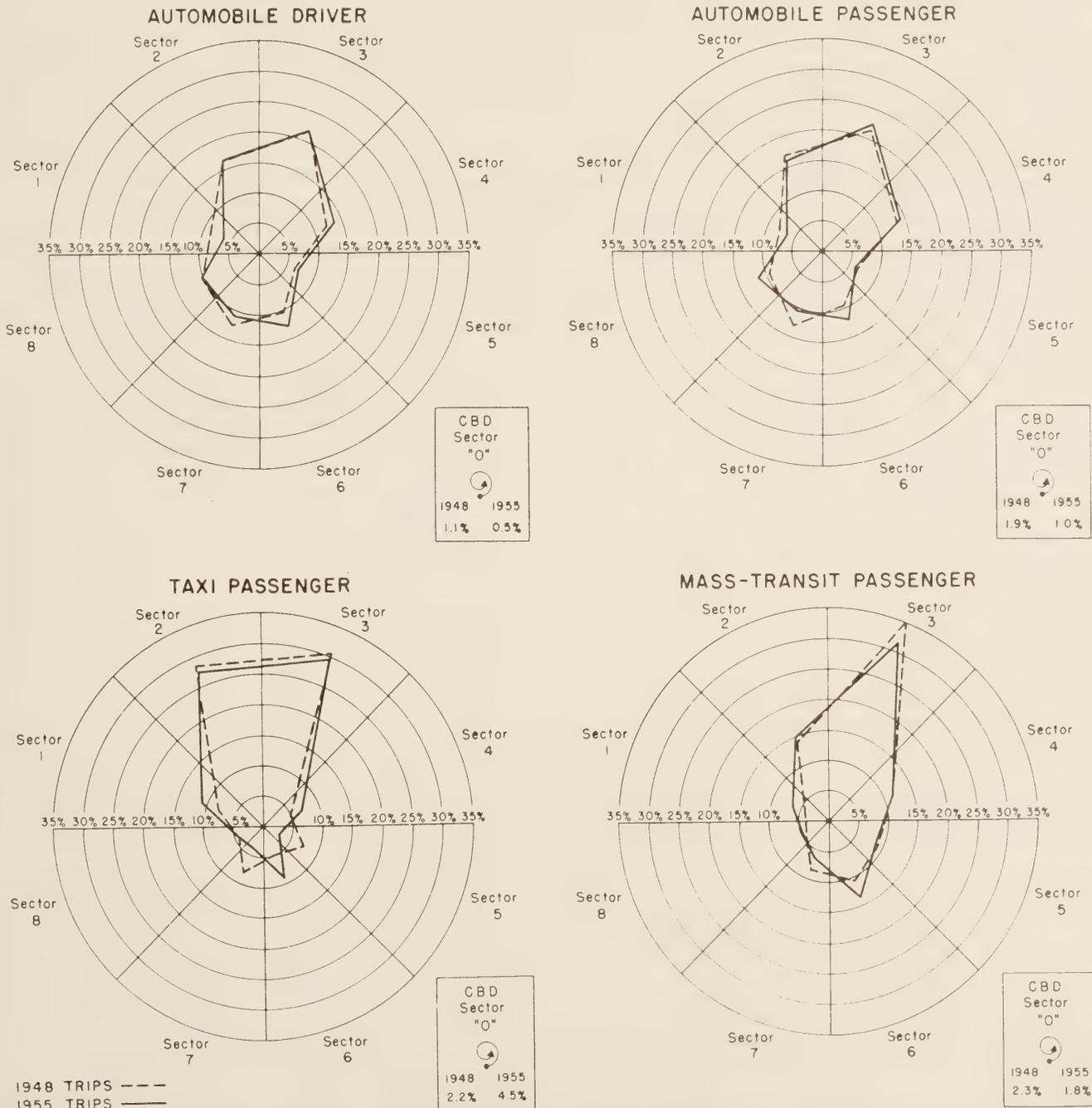
between the sector with the smallest and that with the largest percentage of residents CBD trips by automobile drivers was 15.9 percent in 1948 and 8.0 percent in 1955. If sector 3 is omitted from the comparison, the range is

13.5 percent in 1948 and only 2.6 percent in 1955. Group 2 indicated the same trend; there was a range of 8.0 percent in 1948 and only 1.4 percent in 1955.

The range between sectors in the percentage of residents CBD trips by mass-transit passengers decreased for group 1 from 24.6 percent in 1948 to 12.5 percent in 1955; sectors in group 2 decreased from 9.7 to 5.7 percent. The range in the percentage of trips by automobile passengers decreased in the first group of sectors, but increased slightly in the second group. The range for taxi passengers remained stable between 1948 and 1955 for both groups of sectors.

**Automobile drivers**

The percentage of intra-area automobile-driver trips destined to the CBD decreased for residents of each sector (table 19). The



**Figure 17.—Percentage distribution of automobile-driver, automobile-passenger, taxi-passenger, and mass-transit passenger trips to the CBD, according to sector of residence.**

**Table 21.—Number of trips per 100 dwelling units to the central business district in 1948 and 1955, classified according to mode of travel and sector of residence**

Sectors	Automobile driver		Automobile passenger		Taxi passenger		Mass-transit passenger	
	1955	1948	1955	1948	1955	1948	1955	1948
0	13.3	22.7	15.6	23.9	17.4	9.4	65.8	128.9
1	24.6	37.6	14.3	20.5	6.5	7.1	34.1	53.6
2	20.4	21.2	12.0	13.1	5.3	7.4	26.3	48.3
3	13.8	12.3	8.9	7.7	2.9	3.6	29.6	54.3
4	17.1	15.8	11.1	10.7	1.4	1.4	22.1	41.0
5	14.6	13.4	7.5	8.3	1.0	3.2	24.4	48.5
6	15.2	13.1	9.0	7.6	1.7	1.4	23.9	37.0
7	17.3	17.7	10.2	11.1	.9	2.3	15.4	31.9
8	22.1	26.8	14.5	14.7	1.5	2.4	15.8	30.4
Average, total area	17.0	16.8	10.4	10.3	2.7	3.4	24.7	45.4

largest decreases occurred for the trips by residents of sectors with the greatest number of automobiles owned per dwelling unit in 1948 and 1955, sectors 1 and 8.

The pattern of distribution of automobile-driver trips by residents of each sector varied only slightly from what it had been in 1948 (table 20 and figure 17), even though automobile ownership increased by various amounts in each sector with the exception of sector zero. The percentage distribution changed within  $\pm 1.6$  percentage points of what it had been in 1948 in 7 of the sectors, and in 3 sectors the change was within  $\pm 0.2$  percent. Sector 3 still maintained the major peak of residents automobile-driver trips; however, because of the greater distribution of automobiles and the use thereof in comparison to taxis and mass transit, the peak in

sector 3 is seen to be less extreme in both years than the distribution pattern of the latter two modes of travel.

With the increased number of automobiles owned per dwelling unit, there was a smaller difference between sectors in the number of automobile-driver trips to the CBD per dwelling unit (table 21). The range between the sector with the greatest number of trips and that with the least decreased by over 50 percent in 1955 (25.3 trips in 1948 and 10.8 in 1955).

The relationship between the number of automobiles owned per dwelling unit and the percentage of intra-area automobile-driver trips destined to the CBD changed between 1948 and 1955, as shown in figure 18. In 1948, the plotted symbols indicate no apparent trend. In 1955, however, the percentage of

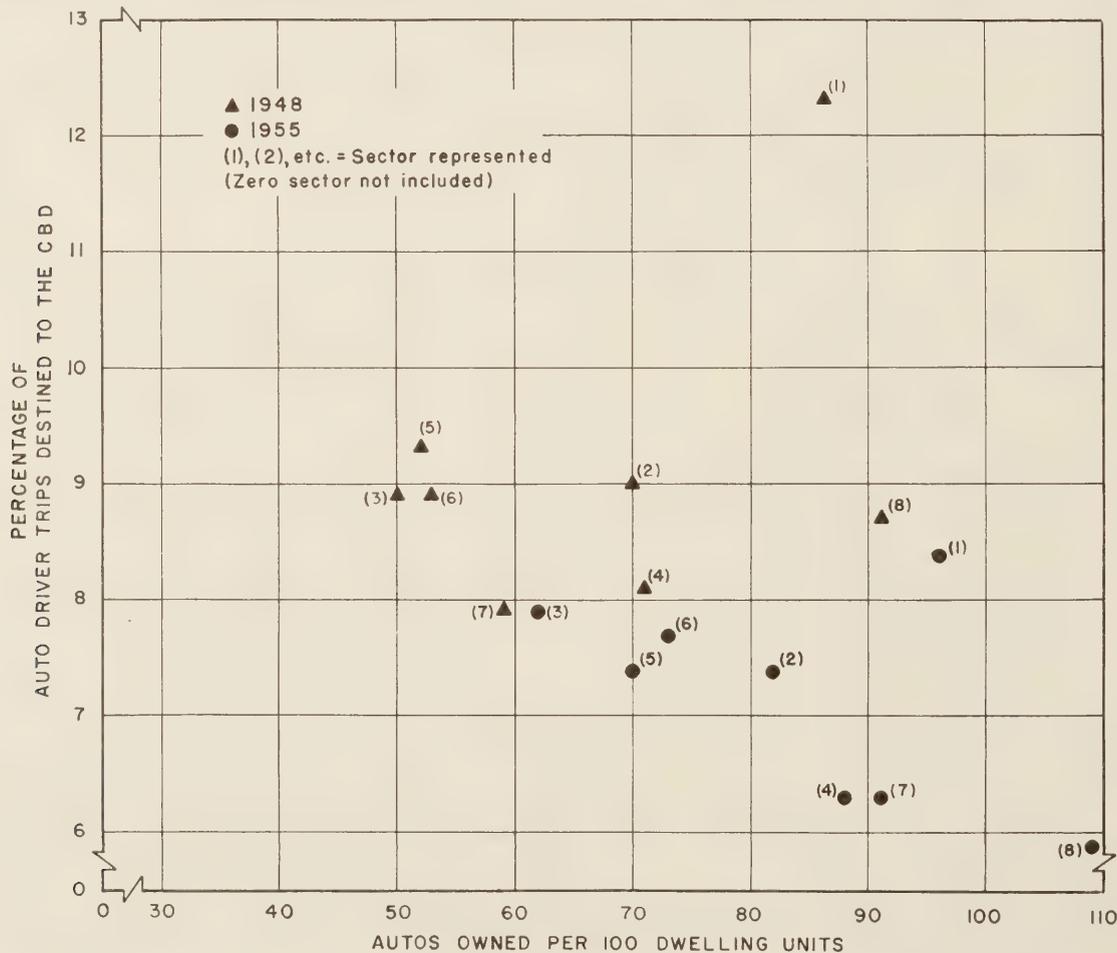
intra-area automobile-driver trips destined to the CBD was generally less for those sectors that had the greater number of automobiles per dwelling unit.

Although work continued to be the dominant purpose for which automobile-driver trips were made to the CBD, the change in the percentage distribution of trip purposes for each of the sectors indicated a general tendency for work trips to decrease in relative importance while "other" trips increased (table 16). Sectors 1 and 7, the two sectors with the highest percentage of 1948 CBD automobile-driver trips made for "other" purposes, were the exceptions.

Another change which occurred was the decrease in the range of purpose distribution for work and "other" purposes between five of the sectors (table 16). In 1948 residents of sectors 1, 2, 4, 7, and 8 had a range in the percentage of their CBD automobile-driver trips for work of 13.4 percent; for "other" purposes, it was 11.7 percent. In 1955 these ranges had decreased to 3.6 percent for work and 1.0 percent for "other" trips. It is interesting to note that these sectors also included the residents who had the highest average incomes in the study area as well as the greatest number of automobiles owned per dwelling unit.

**Automobile passengers**

The relative changes between 1948 and 1955 in the distribution pattern of sector residents CBD automobile-passenger trips were generally small (table 20 and figure 17); six of the



**Figure 18.—Percentage of CBD automobile-driver trips to total area trips related to the number of automobiles owned per 100 dwelling units, according to sector of residence.**

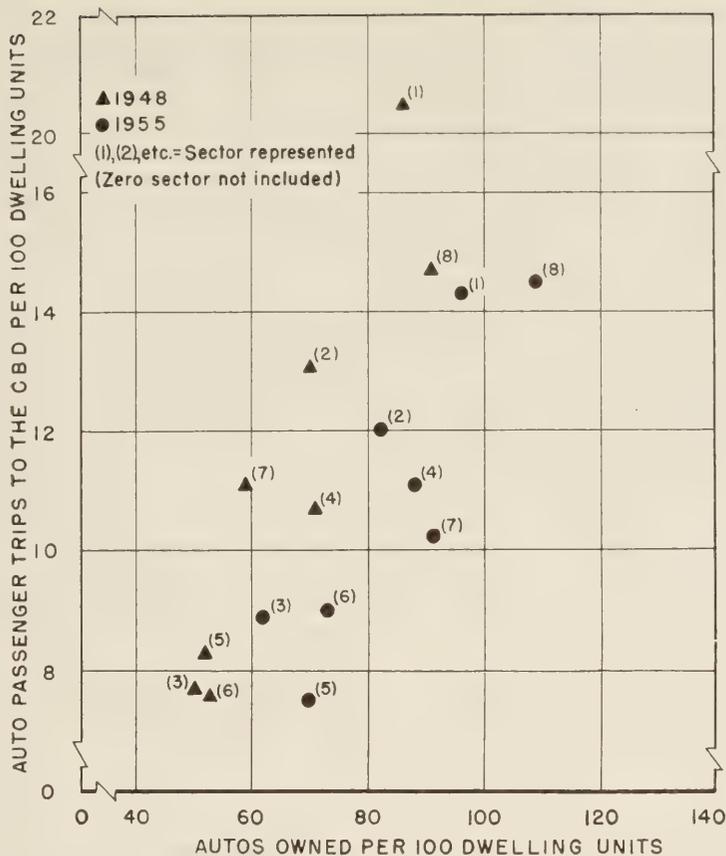


Figure 19.—Relation of the number of CBD automobile-passenger trips per 100 dwelling units to the number of automobiles owned per 100 dwelling units, according to sector of residence.

sectors had a change that was within  $\pm 1.5$  percentage points of the 1948 figure. As indicated in figure 17, the distribution of residents trips in both years showed a pattern very similar to that of automobile-driver trips; and although sector 3 contained the major peak of automobile-passenger trip distribution, as in automobile-driver trips, the peak was not so extreme as the distribution of mass-transit passenger trips.

The relationship between the number of automobiles owned and the number of automobile-passenger trips to the CBD per dwelling unit remained approximately the same, even though the number of automobiles owned increased in each sector except sector zero, and the range of trips per dwelling unit had decreased (fig. 19). The trend in 1955 as in 1948 was for the greater number of automobile-passenger trips to the CBD per dwelling unit to be found in those sectors having the largest number of automobiles per dwelling unit.

The proportion of intra-area automobile-passenger trips to the CBD (table 19) decreased in each of the sectors. Residents of sectors 3 and 6, however, maintained approximately the same percentage. They also had the smallest amount of change in the percentage of their intra-area automobile-driver trips destined to the CBD.

While residents of most sectors made an increasing proportion of their CBD automobile-driver trips for "other" purposes and a decreasing percentage for work, residents automobile-passenger trips showed an opposite tendency (table 16). As mentioned earlier,

car pools were much more common in 1955 than in 1948. In 1948, residents of only one sector made over 60 percent of their CBD automobile-passenger trips to work. By 1955 residents of 7 sectors were in the over 60 percent group, and 4 of these sectors exceeded 70 percent.

#### Taxi passengers

There appears to have been a slightly greater shifting between sectors in the percentage distribution of residents CBD taxi-passenger trips than was indicated in the distribution of residents trips by the other modes of travel; 4 of the 9 sectors had a percentage change greater than  $\pm 3.0$  percentage points (table 20 and figure 17). Nevertheless, in 1955 as in 1948, approximately 60 percent of the taxi-passenger trips destined to the CBD were made by residents of adjacent sectors 2 and 3. As taxi-passenger trips made by visitors were not reported in this study, sector zero does not appear to have a large percentage of taxi-passenger trips.

Except for sectors 0, 4, and 6, taxi-passenger trips per dwelling unit decreased between 1948 and 1955 (table 21). With this decrease, although the difference between sectors was small, the geographical relationship between residents of sectors 1 through 5 appeared to be greater than was apparent in 1948. In 1955 the number of taxi-passenger trips per dwelling unit decreased continuously in the sectors from 1 through 5. This transition again appeared to be one from sectors with high average family incomes to one of lower average family in-

comes. In addition, the relatively lower number of taxi-passenger trips per dwelling unit made by Virginia residents may partially be due to the greater cost of taxi transportation to the CBD than for similar distances in the District of Columbia.

The percentage of intra-area taxi-passenger trips destined to the CBD decreased for residents of each sector, with the exception of sectors 1, 4, and 6. It is not known why the latter sectors did not have the same general trend as the others, for an increase in the proportion of residents trips by any of the modes was unusual. The only other increase was mass-transit passenger trips destined to the CBD by residents of sector 1.

Although the percentage distribution of trip purposes for which CBD taxi-passenger trips were made shifted in each of the sectors, the most significant change was the decrease in the percentage of "other" purpose residents trips in 8 of the 9 sectors (table 16). Taxi-passenger work trips increased in 5 of the 9 sectors, and in 6 of the 9 sectors, 56 percent or more of the taxi-passenger trips were to work.

#### Mass-transit passengers

As in the other modes of travel, there was a shifting between sectors in the relative distribution of total residents mass-transit passenger trips to the CBD (table 20 and figure 17). Nevertheless, the pattern of distribution changed only slightly as 7 of the sectors were within  $\pm 2.0$  percentage points of the 1948 figure and 4 of the sectors were within  $\pm 0.5$  percent. The extremely high volume of trips made by residents of sector 3 can be attributed to the concentration of population in apartments, row houses, and boarding houses, and the relatively adequate transit service for this sector.

Unlike other modes of travel to the CBD, the number of mass-transit passenger trips per dwelling unit decreased in each sector between 1948 and 1955 (table 21). As a result, there was a growing similarity in the number of trips per dwelling unit in all sectors. The area in which the most important decrease took place occurred between sectors 2 through 6. In 1948, the range between the sector with the greatest and that with the fewest number of mass-transit passenger trips to the CBD per dwelling unit was 17.3 trips. By 1955 the range was only 7.5. If sector 3 is excluded in the comparison, the range is 11.5 trips in 1948 and 4.2 in 1955.

Of the percentage of intra-area mass-transit trips destined to the CBD, it was found that only residents of sector 1 maintained approximately the same percentage in 1955 as in 1948 (table 19). The relative decreases that did take place in the other sectors, however, appeared to have a geographical relationship with the CBD. A comparison beginning with sector 2 and moving around the CBD through sector 8, with the exception of sector 6, would show that a progressive increase in the relative changes in orientation took place between 1948 and 1955 (table 19).

Trips to work remained the principal purpose for which sector residents made mass-transit passenger trips to the CBD (table 16). By 1955 residents of each sector, excluding sector zero, were making 60 percent or more of their CBD mass-transit passenger trips to work. Trips made by residents of sectors 7 and 8 are especially noteworthy. By 1955 these residents of Virginia were making approximately 4 out of 5 mass-transit passenger trips for the purpose of work, which indicated the very limited use of mass transit to the CBD for all the other purposes.

## New Publications

The *Annual Report of the Bureau of Public Roads, Fiscal Year 1958*, is now available from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., at 30 cents a copy.

During the fiscal year, the greatly expanded, long-range highway construction program launched by the Federal-Aid Highway Act of 1956 reached full stride. Completions of all classes of Federal-aid and Federal projects provided improvements on 24,204 miles of roads and streets. Projects for the construction of 35,698 miles of improvements were programed and contracts were awarded for 25,912 miles of road and street improvements.

Federal-aid operations of the year were supported largely with funds authorized by the Federal-Aid Highway Act of 1956, although minor balances from previous authorizations were also being used. On August 1, 1957, Federal-aid funds for the fiscal year 1959, authorized by the 1956 act and amounting to \$2.875 billion, were apportioned to the States. An additional \$600 million authorized by the Federal-Aid Highway Act of 1958 was apportioned on April 16, 1958. The total of Federal aid apportioned to the States since passage of the 1956 act was thus brought to \$7.150 billion.

A notable event of the year was the passage of the Federal-Aid Highway Act of 1958. Following traditional practice, it authorized Federal-aid primary, secondary, and urban funds, and funds for construction in Federal lands, for 2 fiscal years, 1960 and 1961. The act increased the Interstate authorizations made in the 1956 act for the 3 fiscal years 1959-61, and set aside the "pay-as-you-go" clause in the 1956 act so as to permit apportionment of the full amounts authorized for fiscal years 1959 and 1960. The act also provided for control of advertising along the Interstate System.

Recognizing the value of highway construction in the Nation's antirecession efforts, the Congress authorized under the 1958 act \$400 million for immediate apportionment to the States for primary, secondary, and urban work. These funds, to be matched on a two-thirds Federal, one-third State basis rather than the usual 50-50 ratio, were required to be placed under contract by December 1, 1958, with work scheduled for completion by December 1, 1959.

The Federal-aid primary, secondary, and urban highway improvement programs progressed on a larger scale than ever before, but the attention of the public was attracted to the Interstate System program. Thousands of people were directly concerned, as hearings on choices of location were held and property for right-of-way was bought. The State highway departments cooperated closely with local officials and planning bodies in selecting locations in the best overall public interest.

During the fiscal year 696 miles of pavement were completed on the Interstate System, but far more was accomplished in surveys and plans, right-of-way acquisition, and grading and drainage construction. At the end of the year \$3.6 billion worth of work was underway or scheduled to start soon.

Two major reports relating to the Interstate System were presented to the Congress during the year. One of these, an estimate of the cost

of completing the system, involved a detailed survey by the States and Public Roads of the 38,548 miles of routes then included in the system. It was found that Federal and State matching financing required after July 1, 1956, amounted to \$37.6 billion, as compared with the \$27.6 billion available from authorizations of the Federal-Aid Highway Act of 1954 and 1956 together with State matching funds.

The other report was prepared in connection with Congress' declaration of intent to determine whether or not the Federal Government should reimburse the States for toll and free highways on the Interstate System built between 1947 and 1957. It was found that 10,859 miles of the system met the criteria for consideration for reimbursement. Construction of these facilities, which included 1,950 miles of toll roads, had cost \$6.09 billion.

Also available from the Superintendent of Documents, at 75 cents a copy, is the revised edition of the publication entitled *Specifications for Aerial Surveys and Mapping by Photogrammetric Methods for Highways, 1958: a reference guide outline*.

This publication was prepared by the Photogrammetry for Highways Committee with active participation by the Bureau of Public Roads. The Photogrammetry for Highways Committee is jointly sponsored by the American Society of Photogrammetry and The American Congress on Surveying and Mapping.

The purpose of the publication is to aid highway officials in establishing specifications for the procurement by contract of photogrammetric and aerial survey services. Under the provisions of the Federal-Aid Highway Act of 1956, the Secretary of Commerce may authorize the use of photogrammetric methods in mapping, and the utilization of commercial enterprise for such services.

The specifications are a reference guide outline, and should be modified to fulfill special requirements not discussed in detail in this publication.

## Lost Mixing Time of Dual Drum Pavers: A Motion Picture

The Bureau of Public Roads, U.S. Department of Commerce, recently produced a new motion picture, *Lost mixing time of dual drum pavers*. The film, based on extensive studies of portland cement concrete paving, conducted by Public Roads, highlights the importance of the simultaneous mixing interval in dual drum pavers in meeting mixing time specifications. It shows some trouble spots and the significance of proper adjustments to the batchmeter. The film had its premier showing at the annual meeting of the Highway Research Board of the National Academy of Sciences on January 6, 1959.

Contractors and engineers will have a particular interest in the contrasting scenes which illustrate why two successive batches of portland cement concrete from a dual drum paver are frequently mixed for a different length of time. The film also illustrates how minimum

mixing time for which the batchmeter is set can be measured. Many of the illustrations are animated cutaway views of concrete being mixed within the mixing drums which, followed by live action scenes of field construction operations, make it possible to follow the mixing process as it actually occurs on the job.

In the tremendous highway construction program now under way, the Bureau of Public Roads has a vital interest in improvement of job management which results in the highest rate of production consistent with quality. Greater attention to what may superficially seem to be trivial problems permits the contractor to offer lower bids on construction work without cutting his profits, and provides the engineer with greater assurance that the end product will meet his standards of quality.

*Lost mixing time of dual drum pavers* is a 16-mm. sound and color film with a running

time of 30 minutes. Prints may be borrowed for showings by any responsible organization by request addressed to Mr. Ray B. Dame, Chief, Photographic Services, Bureau of Public Roads, Washington 25, D.C. There is no charge except for the express or postage fees. Requests should be sent well in advance of the desired showing, and alternate dates should be given if possible. Prompt return after each showing is necessary, so that all requested bookings may be fulfilled.

Prints of *Lost mixing time of dual drum pavers* may be purchased at \$127.45 per copy, the price including film, reel, can, and shipping container, and postage within the United States. Inquiries should be addressed to Mr. Ray B. Dame, Chief, Photographic Services, Bureau of Public Roads, Washington 25, D.C. Payment should not be sent with the inquiry.

# PUBLICATIONS of the Bureau of Public Roads

The following publications are sold by the Superintendent of Documents, Government Printing Office, Washington 25, D.C. Orders should be sent direct to the Superintendent of Documents. Prepayment is required.

## ANNUAL REPORTS

Work of the Public Roads Administration:

1941, 15 cents. 1948, 20 cents.

1942, 10 cents. 1949, 25 cents.

Public Roads Administration Annual Reports:

1943; 1944; 1945; 1946; 1947.

(Free from Bureau of Public Roads)

Annual Reports of the Bureau of Public Roads:

1950, 25 cents. 1953 (out of print). 1956, 25 cents.

1951, 35 cents. 1954 (out of print). 1957 (out of print).

1952, 25 cents. 1955, 25 cents. 1958, 30 cents.

## PUBLICATIONS

A Report of Factors for Use in Apportioning Funds for the National System of Interstate and Defense Highways, House Document No. 300 (1958). 15 cents.

Bibliography of Highway Planning Reports (1950). 30 cents.

Braking Performance of Motor Vehicles (1954). Out of print.

Consideration for Reimbursement for Certain Highways on the Interstate System, House Document No. 301 (1958). 15 cents.

Construction of Private Driveways, No. 272MP (1937). 15 cents.

Criteria for Prestressed Concrete Bridges (1954). 15 cents.

Design Capacity Charts for Signalized Street and Highway Intersections (reprint from PUBLIC ROADS, Feb. 1951). 25 cents.

Electrical Equipment on Movable Bridges, No. 265T (1931). 40 cents.

Factual Discussion of Motortruck Operation, Regulation, and Taxation (1951). 30 cents.

Financing of Highways by Counties and Local Rural Governments: 1931-41, 45 cents; 1942-51, 75 cents.

First Progress Report of the Highway Cost Allocation Study, House Document No. 106 (1957). 35 cents.

General Location of the National System of Interstate Highways, Including All Additional Routes at Urban Areas Designated in September 1955. 55 cents.

Highway Bond Calculations (1936). 10 cents.

Highway Capacity Manual (1950). \$1.00.

Highway Needs of the National Defense, House Document No. 249 (1949). 50 cents.

Highway Practice in the United States of America (1949). Out of print.

Highway Statistics (annual):

1945 (out of print). 1949, 55 cents. 1953, \$1.00.

1946 (out of print). 1950 (out of print). 1954, 75 cents.

1947 (out of print). 1951, 60 cents. 1955, \$1.00.

1948, 65 cents. 1952, 75 cents. 1956, \$1.00.

Highway Statistics, Summary to 1955. \$1.00.

Highways in the United States, nontechnical (1954). 20 cents.

Highways of History (1939). 25 cents.

Identification of Rock Types (reprint from PUBLIC ROADS, June 1950). 15 cents.

Interregional Highways, House Document No. 379 (1944). 75 cents.

## PUBLICATIONS (Continued)

Legal Aspects of Controlling Highway Access (1945). 15 cents.

Local Rural Road Problem (1950). 20 cents.

Manual on Uniform Traffic Control Devices for Streets and Highways (1948) (including 1954 revisions supplement). \$1.25.

Revisions to the Manual on Uniform Traffic Control Devices for Streets and Highways (1954). Separate, 15 cents.

Mathematical Theory of Vibration in Suspension Bridges (1950). \$1.25.

Needs of the Highway Systems, 1955-84, House Document No. 120 (1955). 15 cents.

Opportunities in the Bureau of Public Roads for Young Engineers (1958). Out of print.

Parking Guide for Cities (1956). 55 cents.

Principles of Highway Construction as Applied to Airports, Flight Strips, and Other Landing Areas for Aircraft (1943). Out of print.

Progress and Feasibility of Toll Roads and Their Relation to the Federal-Aid Program, House Document No. 139 (1955). 15 cents.

Public Control of Highway Access and Roadside Development (1947). 35 cents.

Public Land Acquisition for Highway Purposes (1943). 10 cents.

Public Utility Relocation Incident to Highway Improvement, House Document No. 127 (1955). 25 cents.

Results of Physical Tests of Road-Building Aggregate (1953). \$1.00.

Roadside Improvement, No. 191MP (1934). 10 cents.

Selected Bibliography on Highway Finance (1951). 60 cents.

Specifications for Aerial Surveys and Mapping by Photogrammetric Methods for Highways, 1958: a reference guide outline. 75 cents.

Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects, FP-57 (1957). \$2.00.

Standard Plans for Highway Bridge Superstructures (1956). \$1.75.

Taxation of Motor Vehicles in 1932. 35 cents.

Tire Wear and Tire Failures on Various Road Surfaces (1943). 10 cents.

Transition Curves for Highways (1940). \$1.75.

Single copies of the following publications are available to highway engineers and administrators for official use, and may be obtained by those so qualified upon request addressed to the Bureau of Public Roads. They are not sold by the Superintendent of Documents.

Bibliography on Automobile Parking in the United States (1946).

Bibliography on Highway Lighting (1937).

Bibliography on Highway Safety (1938).

Bibliography on Land Acquisition for Public Roads (1947).

Bibliography on Roadside Control (1949).

Express Highways in the United States: a Bibliography (1945).

Indexes to PUBLIC ROADS, volumes 17-19 and 23.

Title Sheets for PUBLIC ROADS, volumes 24-29.

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